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Low Carbon Urban Built Environment

European Carbon Atlas

Editors: Phil Jones, Paulo Pinho, Jo Patterson, Chris Tweed

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Image on front cover

GIS map of an area of Neath Port Talbot County Borough Council with energy use illustrated with different colours – red high energy use, blue lower energy use.

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Introduction

This publication summarises the activities of the COST C23 Action entitled 'Strategies for a Low Carbon Urban Built Environments (LCUBE)' which took place over the period 2004 to 2009. This publication is supported by COST.

The main objective of the COST C23 Action was to investigate, through a network of nineteen countries across Europe,

'*how carbon reductions can be achieved through appropriate design and management of the urban built environment*'.

This involved investigating the built environment at building and urban scale, focusing on minimising energy use and associated carbon dioxide emissions.

The Action investigated how nineteen EU member states were active in reducing carbon dioxide levels in the built environment, not only in line with buildings meeting the requirements of the Energy Performance of Buildings Directive (EPBD) (1), but also in taking standards further and looking at how national and regional planning initiatives are being developed to reduce the energy use of urban areas. A collection of case studies was compiled to illustrate the development and implementation of low carbon strategies at urban and building scales.

Global perspective

It is now widely accepted that some human activities, and in particular carbon dioxide emissions resulting from them, are a major cause of climate change. This, combined with our prolific use of natural resources and the generation of polluted waste, is making human life unsustainable within the context of current aspirations.

Figure I – C23 Action participant countries

The IPCC (Intergovernmental Panel on Climate Change) reported in 2007 (2) that it is 90% certain that climate change is a consequence of human activities. The IPCC also stated that if we are to avoid catastrophic climate change then we must keep global average temperature rise to within 2°C of 2000 levels, which is equivalent to keeping atmospheric carbon dioxide levels below 450ppm. Even then, there is only a 50:50 chance of alleviating the situation.

Perhaps the most dramatic statement, however, is that we have a relatively short time to act. Indeed, if we do not do something substantial within 10 years (from 2007), it will be too late. Under the Kyoto Protocol, accepted in 1997, industrialised countries agreed to reduce their collective green house gas emissions by 5.2% from the level in 1990. National limitations vary, with the EU set at 8% reductions over the five-year period 2008-2012 (3). In the longer term we have to aim for at least 80% reductions by 2050 (4) and carbon neutral planet by the end of this century.

EU targets

Europe is responsible for about 14% of global CO_2 emissions. In Europe, CO_2 emissions are strongly correlated with population size as indicated in Figure II, which is about 10t CO_2 per person (values taken from information supplied by the C23 members).

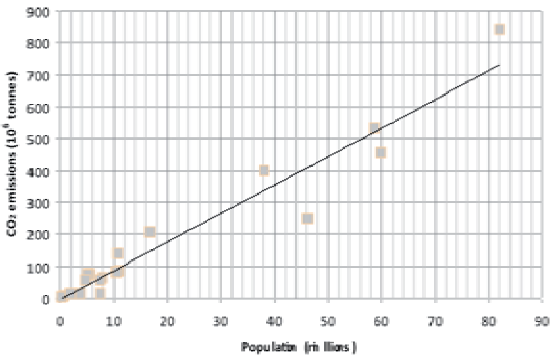

Figure II - CO_2 emissions versus population for 19 EU countries

In March 2007 the EU agreed to reduce emissions to at least 20% below 1990 levels by 2020, and for 20% of energy consumption across the EU to come from renewable sources. Renewable energy currently makes up some 8.5% of the EUs final energy consumption. In addition, the EU has offered to commit to a 30% reduction in greenhouse emissions if other developed countries agree to join in.

The EU has to agree on how to "share the burden" of combating climate change, with countries such as the UK and Germany potentially making much bigger cuts (say 30%) and other high-growth but less developed countries being allowed more leeway. But the EU's original 15 members are apparently currently well short of reaching their Kyoto target of an 8% cut by 2012. China, India and the other emerging economies are perhaps not unreasonably demanding that rich nations follow the implications of the latest climate science and agree to cut emissions by some 40% by 2020 on 1990 levels.

The Built Environment

The built environment, its construction and operation, accounts for a major part of fossil fuel energy use and the associated CO_2 emissions. It also accounts for a large proportion of material resource use and waste production, and associated emissions. Buildings and their supporting infrastructures are said to be responsible for emitting about 50% of CO_2 emissions, possibly rising to 70% if urban transportation is included.

In Europe built environment emissions vary from about 30% for countries in warmer climates to about 60% in the colder and more industrial countries. Figure III illustrates final energy consumption in buildings in 2004. Countries recognise that they are not going to meet carbon reduction obligations from renewable energy alone and therefore energy efficiency is crucial, with some countries setting ambitious targets—for example 70% reduction in residential buildings (Austria).

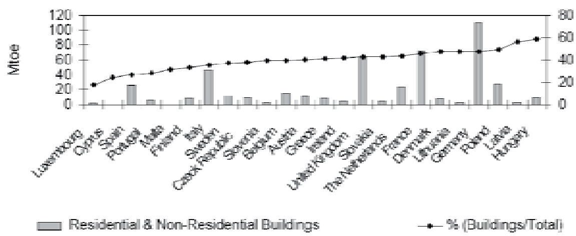

Figure III - Final Energy Consumption in European countries (2004)

Urban planning and infrastructures

The road map towards a low carbon society depends not only on the energy performance and sustainability of the new and existing *building stock* but also, to a significant extent, on the energy performance and sustainability of the *urban structures and infrastructure* that support the urban life and functions of our cities and metropolitan regions. Accordingly, within each national context, the European Carbon Atlas addresses the building scale as well as the urban scale. COST Action C23 was therefore concerned with providing an outline of relevant national planning frameworks, in terms of regulations and guidelines, coupled with selected cities and urban project case studies.

At first sight, and from a pan-European perspective, it seems fair to conclude that, in comparison with the building scale, the urban scale is attracting much less attention from the major players, namely politicians, officials and practitioners. Despite some interesting exceptions, with a few local or regional case studies showing rather advanced and ambitious zero carbon targets and policies, the majority of the European national planning systems covered in our study have not yet produced specific and consistent regulatory frameworks or, at least, clear sets of policy guidelines to support the emergence of a new wave of strategic urban plans or new development control policies to turn our cities into more energy efficient and low carbon built environments.

It should be noted that much of the progress identified in recent years in the construction sector towards more sustainable practices and products in most Member States was a response to EU policies and, in particular, to the approval and implementation of the EPBD through the subsequent transposition of this directive into the national legal and regulatory frameworks. This atlas provides clear evidence of the positive and widespread impacts of the EPBD implementation. However, in the context of the European Union, and under the Principle of Subsidiarity, urban planning is still considered a matter of national, regional and local intervention despite some recent efforts to set up an EU territorial agenda that, in the future, may gradually open the door to a more ambitious intervention of the Commission on these matters.

In the meantime, and in the absence of more proactive planning legal frameworks, the Action has identified some important local initiatives to reduce carbon emissions, some related to planning policies, others related to the adoption of innovative urban infrastructure solutions.

Among the former there are case studies in this Atlas illustrating the adoption of responsive urban policies to reshape existing urban areas along the principles of the compact city model, policies to control and revert sprawl, and the policies to encourage reurbanisation and the emergence of mixed use and self contained urban neighborhoods, in particular, the city case studies of Oslo and Greater Copenhagen.

Many European cities are typified by a historic heart, with large development, often expanding outwards in the post World War Two years, with an increase in urban sprawl and private car use towards the end of the last century. From the 1990's there are examples of more sustainable developments at a larger scale, for example, the solar housing projects including the Linz Solar City in Austria, Albertslund in Denmark and the Pefki solar village in Greece. These projects generally dealt with low energy design through a 'passive design' approach and in particular making use of solar heating through planning layout.

Transport hubs and the compact city concept, typically with inner city 4 to 5 storey blocks has determined the development of many European cities. Although this was largely abandoned with the increase in car use and urban sprawl there is now a return to these principles in many cities, encouraging the shift from private to public transport and the use of bicycles. Successes include Copenhagen, where 'finger planning' promotes development along public transport routes and where the transport split is 1/3 cycle, 1/3 pedestrian, 1/3 public transport and cars, with only 29% car ownership in the inner city. Oslo is also based on the compact city model with reurbanisation since the 1990's replacing the earlier expansion since the 1950's. Now, planning legislation is against urban sprawl with developments along public transport routes. This is also compatible with the increased demand for urban living. In Madrid the transportation split is 53% bus and metro, 34% car and 9% taxi. Zurich also has a. high level of public transport (about 40% of the trips) and with a low number of cars per capita (about 35% in the city, about 50% in the first two development rings). Recent renovation programs include zero car communities.

This shift of emphasis back to public transport is also demonstrated by: the concept of an elevated city rail in Rzeszów, Poland; the public investment in sophisticated urban transport systems, such as light metros in Athens and Belgrade (Belgrade is planning a new light rail for a targeted 40 million passengers per year); fast suburban railways (the case of Zurich) or free shuttle services into town (the case of Valletta and Cardiff – at the planning stage); the improvement of the physical condition of the network of streets and public spaces to further encourage walking and biking (see the case studies of the Cities of Munich and Ljubljana) or facilitate the circulation of taxis and buses (see the city case of Trondheim); and the steady change from the traditional *predict and provide* paradigm in transport planning to the more environmentally friendly *predict and prevent* paradigm.

Two cities involved in the C23 COST Action, Athens and Munich, have benefited from hosting the Olympics. In Athens 50% of trips are now on public transport with 20% associated with taxi's (which are unfortunately currently mainly fueled by diesel), and there are new metro projects to take use from 580,000 per day to nearly 1 million per day. Porto has benefited from its recognition as a European City of Culture, and the 1990's decline in public transport has been reversed since 2005 with a new light rail system. Many cities have ambitions to reduce car use. Trondheim in Norway aims to reduce car use by 20% over the period 2008 to 2018, and to increase public transport use from 42% to 50%.

This provision of public transport services is surely an important step forward towards a low carbon built environment, the adoption of active policies to reduce the daily needs for traveling by individual carbon powered vehicles. A better mix of land use and functions or through relocation policies so that current needs can be satisfied closer to home and/or work, constitute far more adequate and effective urban planning policies. The coordination of land use and transport planning was already the subject of a Norwegian National Policy Provision dating back to 1993. In the UK, reference should also be made to the Planning Policy Statement on Climate Change (2007) making clear that urban planning is expected to contribute to tackling climate change at local level.

Societies are rapidly changing, producing and absorbing new and inspiring ideas and paradigms, such as the *2000 watt society* commitment adopted by the city of Zurich or the *Dogma 2000* adopted by the City Council of Albertslund (Denmark). Indeed, energy consumption depends not only on the physical characteristics of the built environment but also on the dominant societal values and individual life styles. In most European countries, with stable or rather moderate population growth, the increase of single households has been accompanied by a steady return to the city centre very much in line with the search for more compact and lively cities. However, and on the other hand, a larger number of single households also mean a propensity for more floor space per person, and, consequently, the mobilisation of more energy resources.

Reducing CO_2 emissions is not just about reducing energy demand. This should be accompanied by the provision of more efficient and low carbon energy supply systems. There are large scale energy supply initiatives taking place in some cities. For example, in Munich, 50% of heating energy for buildings is from district heating. It has a target to reduce energy by 50% (from 1987 levels) by 2010, mainly in buildings, and car use. Rzeszów in Poland has initiated a number of CHP and SCHP projects. The Chamartin project in Spain aims to reduce building CO_2 emissions by 40% through a central district heating/cooling system and passive design policies. In the UK, Cardiff committed itself to developing a *CarbonLite* city based on improving energy efficiency across all sectors, and there is currently a feasibility study for a large scale biomass heat and power system for its central university and public buildings.

It is also evident that there is a general trend towards deregulation of public services, namely in health and education services. Freedom for choosing the best service is often proclaimed as a right of each and every citizen and as a means to promote a sound competition between the public and the private sector. Parents are often encouraged to choose the best schools for their children, irrespective of their location. What they may not be aware of is that the exercise of that alleged right, extended too many other local services, is contributing to the steady disappearance of the neighborhood unit notion, in its more traditional form, with damaging effects in terms of place identity, social integration and unnecessary inflation of daily trips. The Green Accounts of the City of Albertslund, working at city level, district level and the household level, surely is an interesting approach to assess the overall progress of a local community towards sustainability.

This somehow mixed perspective discussed above is perhaps the reason why some well conceived urban planning projects may not end up producing the results they were expected to. Often they present interesting features and innovative solutions, such as the Solar Village in Greece, the Parque das Nações in Lisbon or the Solar City case study in Linz, but are difficult to blend with normal working, transport infrastructures and mobility patterns of the rest of the city or region that they are supposed to be part of. The most recent experiences of shopping centre planning in Zurich (in particular the Sihlcity case) and the Chamartin project (Madrid- at the planning stage) maybe an exception in this respect, showing that is possible to produce high quality urban spaces and large shopping and service facilities not necessarily dependent on the private car.

Planning policy in the past has in general not focused on energy and CO_2 emissions. However, there are examples where it is including the consideration of energy performance and the application of renewable supply. This is to be encouraged and ‘joined up’ with building regulations.

Clearly, there is a lot of work ahead to be carried out in this field. The legal and regulatory foundations are insufficient. Holistic (but not deterministic) approaches are needed, backed by a more demanding regulatory framework, a sound political commitment and visionary and mobilizing participatory practices anchored in the local community.

Implementation of the EPBD

Directive 2002/91/EC of the European Parliament and Council on energy efficiency of buildings ("Energy Performance of Buildings Directive", EPBD) was passed in December 2002 and came into force in January 2003. The official deadline for the 25 Member States to turn the directive into national law was 2006, although the requirements for certifications and inspections had an additional grace period until January 2009.

COST Action C23 aimed to identify activities for implementing the Energy Performance of buildings Directive (EPBD) within each Member State involved in the Action; and, to gather and critique a range of case studies illustrating state-of-the-art low carbon design and construction in both new and existing buildings. The Atlas presents summaries of the implementation of EPBD across member states and includes case studies of nearly 40 buildings.

Despite the European dimension to the EPBD, there is wide variation in the way that it has been implemented across the different member states. Partly, this is because the starting point for each country was often very different, with some countries (Austria, Germany , UK and others) grafting new regulations on to long established requirements for energy conservation. In other cases, however, the requirement to comply with the EPBD has propelled the development of building regulations that were not previously in force.

Other differences across Member States are apparent. Each country has felt the need to develop its own calculation procedures and software to comply with Article 3. For smaller countries this has been particularly onerous, because they lack sufficient scientific expertise at national level to derive a methodology that takes account of their specific climatic or energy circumstances and because the potential market for software is too small to encourage commercial development of calculation software.

There are differences in the approach adopted within the calculation procedures: some are based on the performance of a 'notional' building against which the actual design is compared, whereas others set absolute standards for the performance of new buildings. Some countries use a single method for all building types; others have developed separate packages. Similarly, cooling energy is absent from some calculations (UK and Ireland), but present in other procedures. Another notable difference across calculation procedures is that some countries have focused on primary energy consumption and CO_2 emissions, while others are only interested in the energy consumed directly by the building.

As well as the differences in calculation procedures, there are differences in measuring floor area, for example, and in the treatment of thermal bridging that undermine attempts to develop Europe-wide procedures and software. These serve as a reminder that the variation across Member States is not merely climatic but in the way different cultures respond to their climates.

Given the wide variation in approaches to calculation, it is not surprising that similar variations are found in the design of Energy Performance Certificates. These vary in the type of graphical display used to communicate the performance band in the amount of information provided on the certificate.

In all cases, the speed at which the EPBD was required to be implemented proved a problem, even for countries with a long track record of legislation addressing energy in buildings. Few of the Member States were able to meet the demanding timetable and some are still struggling to fulfill all the requirements today, for example, in developing a comprehensive calculation procedure. This is an important lesson about the inertia inherent in legislative systems. Delays in the authoring, enactment, implementation and enforcement of new energy regulations are inevitable and need to be taken into account during their design. Further delays in the delivery of compliant buildings were not discussed in any depth within the Action, but representatives reported informally on severe problems for the construction industry in many countries in developing the knowledge, skills and supply chain needed to deliver low carbon buildings. In some countries it may be many years before low carbon buildings become the norm.

Low carbon buildings

The case studies relating to buildings show a wide range of approaches and technologies. There are examples of new buildings and refurbishment of existing stock and varying degrees of experimentation in the application of novel heating and cooling technologies. Again, as with the implementation of the EPBD, it has sometimes been difficult for smaller countries to identify landmark low carbon developments, mainly because momentum is only now gathering to design and construct to more exacting energy standards. There is a fairly clear asymmetry here in that countries where heating is the normal requirement seem farther along the path to low carbon futures, perhaps because they currently consume more energy keeping warm than others do in keeping cool, even though cooling is more energy intensive.

Many of the cases exhibit features that might reasonably be expected in most modern low energy buildings. However, some cases demonstrate state-of-the-art technologies such as air-source heat pumps (Belgium) and translucent thin-film photovoltaics (Norway). While energy converting technologies will always be essential, many of the cases reinforce the argument for reducing demand through careful attention to the principles of low energy design: orientation, passive solar features, high levels of insulation, etc. In terms of reducing CO_2 emissions, a kWh reduction in demand is worth much more than a kWh converted, because of insurmountable conversion inefficiencies

Many countries are seeking to encourage higher performance standards for energy use through a range of schemes, including Minergie in Switzerland and the Code for Sustainable Homes in the UK. Some countries have set a series of targets to reduce CO_2 emissions, typically a 25% reduction every five years. The German *Passivhaus*o standard has been adopted for low energy design across Europe. It calls for a heating demand below 15 kWh/m^{2}a and heating power below 10 W/m^{2}a. The primary energy demand should be less than 120 kWh/m^{2}a. Some countries have introduced grant aid and tax incentives to encourage energy efficiency.

Much of the focus to date has been on the design of new buildings. However, although it is important to design new buildings to a high standard in terms of minimising CO_2 emissions, it is the existing building stock, at an individual building and urban scale, where the main effort needs to be applied. There are many good example of how existing buildings can reduce their CO_2 emissions. Case studies from the nineteen C23 countries include examples of CO_2 emission reductions ranging from 60% to 90% for existing buildings, some to *Passivhaus* standards. For such schemes, payback periods have been as good as nine years. Measures typically include increasing levels of thermal insulation, new highly insulated glazing and new efficient heating systems. Some have more advanced solutions such as introducing a glazed double skin to wrap the building, and in one case (Norway) integrating solar PV into the external glazed skin.

Many countries have major social housing problems where energy use is high and often residents are in a situation of fuel poverty, that is, when a significant amount of their income is spent on energy for the home (in the UK greater than 10%). There are large scale schemes, for example in Wales, where 60,000 houses were surveyed and relatively low cost energy efficiency measures were applied to reduce energy use on average by 10% and take many people out of fuel poverty. In Jesenice, Slovenia, public housing built in the period 1945-1980, which was being poorly maintained, has now largely been privatised. It was in need of intensive renovation, due to changes in function, energy and environmental challenge and high running costs. The city district heating company identified over 40 buildings (1,400 flats) with delivered energy consumption for heating exceeding 150kWh/m2a, where interventions are needed. As a part of the scheme and in cooperation with the local authority the measures have been prepared to help large residential buildings in Jesenice develop sustainable maintenance and renovation projects with energy savings predicted to reach up to 45%.

For new buildings, zero carbon or carbon neutral performance is the ultimate aim to mitigate against further climate change. This means reducing energy demand and then using renewable energy supply, either integrated into the building design or near-to as part of a community based renewable energy system. Generally speaking, the renewable energy system should be part of the development and not assumed to come from existing green energy sources. In the UK the policy is that all new housing and schools will be zero carbon by 2016. In Wales, the regional government aspires for all new buildings to be zero carbon by 2011. This is a big challenge and although there are few truly zero carbon buildings to date, there are some good examples of how we might get there. Examples from COST Action C23 include some autonomous buildings (zero carbon) and a number of buildings where typically 75% savings have been achieved over current standards. The increased costs associated with achieving such savings need not be high, and most examples investigated showed increased costs of between 0% and 6%. Many innovative measures have been identified as well as simply high standards of good passive design. Attention to thermal bridging is important and access to solar heat gains through good planning layout and the control of solar heat through shading. Heating and cooling, using ground source heat pumps have been used and ground air pipes for pre-heating and pre-cooling ventilation air have in some cases (for example the EMPA office in Zurich) eliminated the need for mechanical energy-intensive systems. Renewable energy from solar thermal and solar PV is common in many of the building case studies.

The development of individual cases, ironically, highlights the dangers of treating buildings in isolation. The phenomenon of 'green sprawl' emerged from discussions about the shortsightedness of building new low carbon dwellings far from city centres thus encouraging citizens to leave less energy efficient properties in the city centre, and then commute on a daily basis to jobs located in the centre. This underlines the need to work across scales in developing low carbon solutions for cities and regions. This is evident in the increasing number of neighbourhood or district heating and cooling schemes, often with interseasonal storage. A major debate needs to take place, therefore, around the appropriate scale of provision for the different generation and storage technologies.

Changes during the life of the Action

There have been major changes since the Action began in 2005. Most notably, many parts of the world have suffered an economic downturn which, in some countries, has amounted to a recession to rival that of the early 1990s and in extreme cases, the 1930s. Members of the Action reported varying degrees of economic crisis and some reported on government interventions to support the construction industry and simultaneously boost progress towards carbon reduction targets. Austria, for example, has offered incentives for improving energy performance that have helped keep its construction industry buoyant during this difficult period. Similarly, Italy is offering financial support for the renovation of existing buildings. and in Germany, state banks are offering preferred loans for improvements—the better the improvement, the bigger the loan. Switzerland also reported no major crisis in the construction industry because of greater activity in renovation.

The EPBD has undoubtedly provided a driving force for many of the new initiatives now in place or under development in Member States, but it is encouraging to see some countries recognise the need to reduce carbon emissions beyond the remit of the built environment. Switzerland's "2000W Society" has gained momentum and reveals the stark choices that need to made: for citizens to retain the same levels of mobility they currently enjoy., they will need to live in dwellings that consume little or no energy. Taking this idea even further, there are plans for 'active' rather than 'passive' houses that will generate more energy than they need for thermal comfort, light and power. Such buildings become positive assets in achieving a zero carbon society.

Methods for designing and constructing low energy/carbon houses have also been boosted by the requirements of the EPBD. The most notable of these is the German *Passivhaus* standard, which has gathered momentum in many countries and is now being applied to other building types, e.g. schools, offices and hospitals. *Passivhaus* and other similar standards have rekindled interest in offsite construction, which is seen by many as the most effective way to achieve the quality demanded by low and zero carbon buildings.

Advances in solar photovoltaic (PV) technology suggest new applications for buildings. The development of low cost, though low efficiency (5%), thin layer PVs invites new large scale deployment on external surfaces. Thus, while the cases presented here tend to underplay the use of PVs, perhaps they may eventually be given a slightly more prominent role. In Germany, for example, companies have begun to rent roof space to place PVs that will harvest solar energy in a large scale.

However in spite of greater attention to energy efficiency to reduce heating and cooling demand and an increase in renewable and low carbon energy supply, there is an overall increase in the use of lighting and small power in buildings.

New standards and construction methods require new tools for simulating building performance, and in general these have improved and multiplied. In many cases, these have responded directly to the requirements of the EPBD. Mostly, however, the emphasis has been on producing tools that test for compliance rather than on increasing the understanding of how low carbon buildings work.

At an urban scale, household demographics continue to change with increases in floor area per person and an increase in single person households, negating some benefits of higher standards of energy efficient design. The privatisation of public transport is restricting cities effective powers to encourage modal shift and daily travel is increasing due to deregulation of public services, such as schools and hospitals. However there is some indication that planning regulations may pay more attention to CO_2 reductions in the future.

Conclusions

The general findings of this Atlas indicate an increase in the use of public transport, a trend towards higher density urban living and low energy design associated with both new build and refurbishment. Countering these CO_2 reductions are, a growth in mobility, greater floor area per person in buildings and an increase in electrical use for lighting and small power.

To achieve long term reductions in CO_2 emissions, reducing energy demand must be the first action. Buildings must be designed to be as near 'zero carbon' as possible, existing buildings must be modified to make considerable reductions in energy use, urban transportation must be designed in harmony with building development, and renewable energy supply and storage mechanisms must be applied to the urban built environment. COST Action C23 has shown that such large reductions in carbon dioxide emissions are possible and affordable, and many example of good practice exist. The work has indicated that a holistic but not deterministic approach is needed across the built environment. This includes the consideration of existing and new buildings together with the transport systems that support them.

However although many good examples exist to demonstrate what is possible, the rate of uptake is slow, not necessarily because the technology is difficult or the costs are high. It is more about changing the mindset of planners, designers and the construction industry, so that innovation and new ideas are accepted by what is generally considered to be a risk adverse industry. Politicians must also put in place regulation and legislation to roll out more ambitious low carbon strategies to reach targets necessary.

To some extent the 'system' has evolved to resist the change to greater sustainability. There are issues relating to the way built environment projects are costed and procured, together with the general concern by people and organisations to change. But there is also a growing concern over the environment and that a more sustainable way of living can also be a better way of living. Reducing CO_2 emissions through planning and design need not be seen as negative or restrictive. It will result in a cleaner, better quality of life with greater inclusivity and affordability. The green economy has been identified as an area where development and wealth creation without environmental harm can be achieved. There is a need not only to understand the process of planning and design for sustainability, but also to understand the everyday practices of peoples lives, that buildings form part of, and for the built environment to encourage a broad range of sustainable lifestyles for individuals, communities and organisations.

Acknowledgements

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I Austria

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National context

The Republic of Austria, (in short: Austria) comprises nine federal states and therefore building laws in general are under the responsibility of these nine Austrian provinces. On the certification itself a federal law (civil law) has passed the Parliament.

Climate

Austrian climate is influenced by interaction of ocean climate on one hand and by continental climate one the other. Therefore there is in the east a typical cold winter and a hot summer, combined with rather low intensity of rain. In the western parts of Austria the climate features are not so extreme. The mild winter is followed by a moderate summer. The intensity, however, of rain is relative high. Due to the topographical features there is also the alpine climate relevant for Austria. Where there is a strong winter predominant. In general Austria is part of the middle-European transition climate zone with regional aspects due to the Alps and the panonian area in the east. In winter there is due to a continental high the probability of sunshine and heavy cold (up to -20 ºC). The time of sunshine is up to 10 to 20% higher compared to north-Germany for example. Heating period runs from middle of October to middle of April and results in a high energy demand due to a rather long transition period and peak low temperature up to -37.2 ºC (Sonnblick-peak in Salzburg on 1st January 1905). The lowest temperature in urban area (Zwettl, lower Austria) was -36.6 degree Celsius on 11th of February 1929. The highest temperature in urban area (Dellach in Drautal, Carinthia) was 39.7 ºC on 27th of July 1983. Fall 2006 is considered to be the hottest since weather monitoring, and winter 2006/ 2007 is qualified as hottest since 1900.

According to the relative easement of oceanic climate along the west-east axis the quantity of rainfall lowers also. The quantity of rain and snow in Vienna is about half compared to Salzburg. Areas with the most rain shower are along the North of the Alpine region with up to 3,000 mm rain/snow per year. The average is around 900 mm. In spring and fall the range of temperature allows snow up to heavy heat. In July and August temperature is above 30ºC and due to high humidity heavy thunder storms can take place.

Demographics

At the April 2007 Austrian Census, the total population of Austria was 8,032,926.

Energy in Austria

Figure I.i shows the change of prime energy suppliers from 1974 to 2004 in oil, gas, renewable energy and electricity.

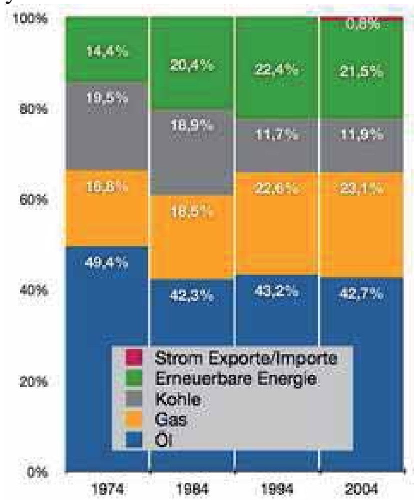

Figure I.i – Prime Austrian energy suppliers from 1974 - 2004

The total energy in 2003 was 1.398 Peta Joule. 76% of it was produced by fossil fuel, 12% by water power and 12% by renewable energy. Inland production (31%) of energy in 2003 was provided by 38.6% of bio-mass energy, 29.9% by water power stations, 17% by gas and 11% by oil and 2.6% by coal. In 2004 the proportion of Russian gas was 58.6%. The energy end-user figure in electricity is 59.354 Gigawatthours (GWh) in 2003, being 5.3 Terawatthours (TWh) or 10% higher than 2002.

Legal context

Energy performance requirements

The Federal Republic of Austria is responsible for implementing the EPBD when the energy certificate involves the selling or renting of buildings or parts of a building (apartments, offices etc.). On 24th May 2006 the Austrian Parliament has passed the Energy Certification Providing Act which obligates vendors and landlords to provide energy certificates for buildings when they are sold or rented. The law refers to the county (Länder) regulations as far as methodologies, requirements and procedures are concerned.

In order to harmonise the nine building codes and other legislative elements of the counties the OIB (Austrian Institute for building technology) was charged with the development of a calculation system, the details of which, and the definition of the EPBD requirements can be found. Based on these standards the counties have finally adopted their regional legislations.

Title of the ÖNORM		ÖNORM number
Energy requirement	Heating and cooling demand	ÖNORM B 8110-6
	Energy use for ventilation and air conditioning	ÖNORM H 5057
Final energy demand	Energy use for heating systems	ÖNORM H 5056
	Energy use for cooling systems	ÖNORM H 5058
	Energy use for lighting	ÖNORM H 5059

Table I.i – Table illustrating the Austrian Standards used with regards to calculation methods

In addition, the "Guidelines concerned with the energy performance of buildings" constitute a technical annex to the Austrian Institute for Structural Engineering Guideline 6 "Energy economy and heat retention". These guidelines contain general provisions, the final energy demand calculation, the simplified procedures and measures which are recommended for existing buildings. Since the different legislative elements comprising the whole implementation of the EPBD can only be found in the diverse Länder codes. Otherwise, the following ÖNORMs (Austrian Standards) should be consulted with regard to the calculation method.

EPBD implementation

Energy performance certificate

Much experience has been gained in those counties (Carinthia, Upper Austria, Salzburg, Steiermark and Vorarlberg) which have already produced more than 70,000 energy performance certificates before implementing the EPBD. These certificates did not include heating, cooling and lighting and will therefore be revised.

With the OIB Directive 6 coming into effect (via county-building codes), the issue of an energy performance certificates for newly erected buildings and for major renovations (if the renovation includes at least three of the following elements: floor, walls, windows and doors, roof, heating and/or cooling system) is mandatory.

From 1st January 2009 it will be mandatory that when buildings are sold, re-sold or rented out, an energy performance certificate is made available to the owner or to the potential buyer or tenant by the owner (see federal law for the mandatory presentation of energy performance certificates). The certificate is valid for ten years. It may be extended for another ten year period after examination by the issuing authority or an equivalent expert, as long as there have been no changes affecting the energy performance and the legislation has not been altered. Each energy performance certificate is only valid for the parts of a building of equal usage, for which the certificate's input parameter has been determined.

The following buildings or building categories are exempt from the requirements:

- Buildings and architectural monuments; buildings used as places of worship and for religious activities which are specifically protected as part of a designated environment or due to their particular architectural or historical value, where compliance with the requirements would unacceptably alter their nature or their outward appearance and the requirements could otherwise not be met.
- Buildings which do not serve residential purposes and which are not conditioned.

- Buildings which do not serve residential purposes and which have energy demand of less than 680 degree days.

The energy performance certificate is to be designed according to provincial legislation. An energy performance certificate issued for a building/part of a building (zone) applies to every unit of similar usage building/part of a building. The subdivision into parts of a building with different usages remains unaffected by this. The determined Energy performance indices are based on standardized use.

In public or partial public buildings with a total useful floor area of over 1000 m^2 (conditioned gross surface) which are not exempt from the requirements (these include office buildings, administrative buildings, education buildings, hospitals, nursing homes, guesthouses, hotels, restaurants, event buildings, sports facilities, wholesale and retail trade service buildings), an energy performance certificate of less than ten years old is to be placed in a prominent place, clearly visible to the public.

The energy certificate must be drawn up by qualified and authorised individuals. It must consist of:

- a first page with an efficiency scale;
- a second page containing detailed results; and
- an Annex which must satisfy the stipulations of the rules of the trade.

The Annex must specify in detail which available ÖNORMs and aids (e.g. software) were used in its preparation. Professional software has been developed by several institutions, all of them exactly basing on the algorithms of it which had to be proved; otherwise, a reference building would have to be calculated to determine if the results were the same. The Annex must also indicate how the input data (geometric and utility entry data, as well as data relating to the building physics) were determined.

Efficiency scale levels for the graphic representation of the annual heating demand HWBBGF, Ref per m^2 of the conditioned gross area and relative to the reference climate are fixed according to the guidelines published by the Austrian Institute of Construction Engineering for residential and non-residential buildings. According to the option of introducing labelling for energy performance indices by the EPBD, it was agreed to introduce such labelling for the already familiar factor "thermal heating demand" (in kWh/m^2a) until further notice. The following values are to be considered for its assessment:

Class A++: HWBBGF, Ref ≤ 10 kWh/ m^2a
Class A+: HWBBGF, Ref ≤ 15 kWh/ m^2a
Class A: HWBBGF, Ref ≤ 25 kWh/ m^2a
Class B: HWBBGF, Ref ≤ 50 kWh/ m^2a
Class C: HWBBGF, Ref ≤ 100 kWh/ m^2a
Class D: HWBBGF, Ref ≤ 150 kWh/ m^2a
Class E: HWBBGF, Ref ≤ 200 kWh/ m^2a
Class F: HWBBGF, Ref ≤ 250 kWh/ m^2a
Class G: HWBBGF, Ref > 250 kWh/ m^2a

A scaling for the final energy demand and other factors are also displayed in the energy performance certificates. Since energy saving and efficient use of energy are – besides forced use of renewable energy sources – the main objectives in Austria in order to become more independent, the first results can be observed as the introduction of an increasing number of passive buildings etc. a Class A++ (heat demand ≤ 10 kWh/m^2a) and a Class A+ (heat demand ≤ 10 kWh/m^2a). The public notice obligation comes into force on 4 January 2009.

Energy certificates for new buildings have already come into force, and for existing buildings will come into force on 1st January 2009 according to the counties regulations. The certificate has to be provided with the draft contract; in addition, if an agreement is concluded, the certificate has to be given to the buyer or tenant. In general, certificates will be issued for the whole building, but the new law also allows for certificates for apartments or parts of a building with specific use (e.g. salesrooms, business offices).

Calculation procedures

The heating and cooling demand is calculated in accordance with the guidelines published by the Austrian Institute of Construction Engineering. A sophisticated calculation system has been developed, including authentic descriptions of buildings, based on more than 200 mathematic algorithms providing differentiated descriptions covering most of the details used in conventional and special purpose buildings. The user of this system has the opportunity to use all available details, but is not obliged to do so, and can do the calculation instead using the default values.

Assignment to the "residential building" category is based on the building's primary use, provided other uses does not exceed a conditioned net area of more than 50 m^2 or a 10% share of the conditioned gross area. If this proportion is exceeded, the building must be divided up, into individual parts that must be assigned to the "residential building" or "non-residential building" categories. This requirement is reviewed separately in connection with the individual parts of the building. As regards non-residential buildings, a distinction must be drawn between 11 categories of building.

In order to make the calculation system as authentic as possible, several additional features have been developed as a climate model by collating monthly climate data especially for heat storage in relevant parts of the buildings and other purposes and a methodology to calculate the economic and environmental status and effects of the use of renewable energies for new and existing buildings. In Austria renewable energies have already a share of 25% of the overall energy consumption and this is expected to increase. As CEN-standards have reached the stage where the methodologies should only be subject to minimum change, they have been implemented, and will guarantee a high compatibility of the Austrian calculation methodology to a future harmonised European methodology to the largest possible extend.

A simplified methodology for existing buildings has also been developed using the experience of the various Austrian energy consultants and the energy consulting offices of the nine counties, especially in Vienna which is the owner of more than 200,000 buildings and apartments, in order to be able to finalize the building certificates by 2009.

Requirements for new residential buildings and major renovations

Generally, Austria has introduced a system of requirements which will be continuously implemented, finally leading to a passive building standard for all kinds of buildings (except historical buildings etc.). As a first step, the following maximum permitted annual heating demand HWBBGF, WG, max, Ref per m^2 of the conditioned gross area must be observed, depending on the geometry (characteristic length lc) and relative to the reference climate according to the guidelines published by the Austrian Institute of Construction Engineering: In the case of buildings with a ventilation system with heat recovery for the living areas, the maximum permitted annual heating demand is reduced by 8 kWh/m 2a.

Requirements for new non-residential buildings and major renovations

The following maximum permitted annual heating demand HWB*V, NWG, max, Ref per m^3 of the conditioned gross volume (calculated using the user profile of the residential building) must be observed, depending on the geometry (characteristic length lc) and relative to the reference climate according to the guidelines published by the Austrian Institute of Construction Engineering:

In the case of **buildings with a heating, ventilation and air conditioning system with heat recovery**, the maximum permitted annual heating demand is reduced by 8kWh/m^2a or 1kWh/m^2a unless more than half of the useful area is supplied by a heating, ventilation and air conditioning system with heat recovery.

In the case of **non-residential buildings** in the above mentioned building categories either overheating in the summer (as per ÖNORM B 8110-3), in which consideration must be given to the actual internal loads, or the maximum permitted externally induced cooling demand (residential building user profile, infiltration nx = 0.15) per m^3 of gross volume of 1.0 kWh/m^3a must be observed.

The heat transfer coefficients (U-values), as illustrated in Table I.ii, should not be exceeded in relation to the heat-transfer building components when constructing a new building as well as when replacing or repairing the building component in question in air conditioned rooms.

Building component	0.35
External WALLS	0.35
Small WALL areas facing the external air (e.g. in the case of skylights) which do not account for more than 2% of the walls of the building as a whole which face the external air, provided ÖNORM B 8110-2 (absence of condensate) is observed.	0.70
DIVIDING WALLS between residential or commercial units	0.90
WALLS facing unheated parts of the building which are to be kept free from frost (with the exception of roof voids)	0.60
WALLS facing unheated roof voids or those that have not been extended	0.35
WALLS facing other structures along the boundaries of plots of land or building sites	0.50
WALLS AND FLOORS WHICH ARE IN CONTACT WITH THE GROUND	0.40
WINDOWS, FRENCH WINDOWS, GLAZED or UNGLAZED DOORS (relative to the test standard measure) and other vertical TRANSPARENT BUILDING COMPONENTS facing unheated building parts	2.50
WINDOWS and FRENCH WINDOWS in residential buildings facing the external air (relative to the test standard measure)	1.40

Other WINDOWS, FRENCH WINDOWS and vertical TRANSPARENT BUILDING COMPONENTS facing the external air, GLAZED or UNGLAZED EXTERNAL DOORS (relative to the test standard measure)	1.70
ROOF WINDOWS facing the external air	1.70
Other TRANSPARENT BUILDING COMPONENTS facing the external air, horizontally or at an angle	2.00
CEILINGS facing the external air, roof voids (thoroughly aired or not insulated) and above passages as well as SLOPING ROOFS facing the external air	0.20
INTERNAL CEILINGS facing unheated parts of buildings	0.40
INTERNAL CEILINGS facing separate residential and commercial units	0.90

Table I.ii - Heat transfer coefficients (U-values)

There are additional requirements regarding heat distribution, heat accumulators, heat recovery, avoidance of thermal bridges, atmospheric and wind proof density, prevention of overheating in summer, central heating installation and alternative energy systems.

Qualified experts

It is assumed that this energy performance certificate is also required for new buildings and major renovations, when the building permit is issued. To determine the data for the energy performance certificate according to Article 7, experts accredited by the rules and regulations relevant to their occupation are to be consulted.

- Chartered engineering consultants with relevant authorisation;
- Engineering agencies of expertise within their trading licence, master builders and master carpenters;
- General legally accredited experts in the relevant areas of expertise;
- Technical departments of public enterprise bodies.

For these authorised parties there is no obligation to do a training course or take exams since it is assumed that relevant training should have been received for accreditation. Most experts are, in fact, aware of a lack of knowledge especially with regard to the calculation procedures and take a specialised training course without being obliged to. Training is offered by the regional governments together with the Chambers of Commerce and of Civil Engineers.

The energy performance certificate must be issued by an authorised person according to the relevant rules and regulations of the trade, an accredited inspection authority or certain civil engineers (i.e. architects). For independent experts for the inspection of boilers, the requirements of ÖNORM EN 15378 “Heizanlagen in Gebäuden – Inspektion von Heizkesseln und Heizsystemen” apply. For independent experts for the inspection of air-conditioning and ventilation systems, the requirements of ÖNORM EN 13313 apply.

Inspection of boilers

In Austria, the regular inspection of heating systems has been carried out for many years. The frequency of inspection depends on the energy source and the size (power) of the heating system (from up to four times a year for solid fuels to once a year for gaseous fuels). So the relevant article of the EPBD can be seen as having been implemented except the 15 years one-off-inspection, which will be introduced together with the building certificate which a new methodology has been developed for. In future, relevant existing Austrian regulations will be adapted to the future CEN-regulations - as far as these are at least as strict as the Austrian ones since Austria will not give up its high environmental standards. EN 15378 “Heizanlagen in Gebäuden – Inspektion von Heizkesseln und Heizsystemen” (heating systems in buildings – inspection of boilers and heating systems) applies.

The inspection obligations for heating installations which have been in use for more than 15 years came into force on 1 st January 2006 (a one off-inspection). The inspection reports must be available by 1st January 2009 at the latest, and be registered in the “Gebäude- und Wohnungsregister” (GWR = Central Austrian register of residential and non-residential buildings); some counties (Bundesländer) have an additional provincial register which communicates with the GWR.

The final new draft on the nature and scope of the inspection resulting from the new “Vereinbarung über Heizanlagen according to 15a BV-G” (agreement between the federal Länder and the Republic of Austria on heating systems according to article 15a of the constitutional law) is currently being further processed in the FNA 058-11 of the Austrian Standardization Institute.

Inspection of air-conditioning systems

As cooling devices have so far not been regularly inspected, it was necessary to develop requirements as well as a calculation methodology. Since there were no independent experts in this field, the additional three year period (until January 2009) will be used by the federal nine counties.

Cooling systems from 12kW rated output (refrigerating capacity) as well as all air-conditioning systems for the technical conditioning of buildings are to be inspected (the power of several installations within a building has to be summarised). Three inspection intervals (annually, every 3 years, every 12 years) are to be carried out. The inspection is to be carried out according to the engineering rules. The levels of the three inspection modes are very different starting with a rough estimation of the efficiency of the installed system and a visual check for the annual inspection, up to efficiency measurement and calculation and a detailed check for the 12-year inspection. Since it is important to minimise the costs of undertaking the annual inspections, it only comprises the collection of important information which will help to evaluate the energy use and identify potential energy conservation opportunities consisting of:

- Analysis of the "as built" files, including design calculation and commissioning results;
- Analysis of the information made available by the building manager: consumptions, running expenses, failures and maintenance records, occupancy and complaints records.

The 3-year inspection should establish, through an inspection of the system and quick and simple measurements, the overall energy performance and indoor air quality standard. The inspection procedure consists of measurements of the air quality, energy consumption, air flow rates, etc., with accompanying photographs and descriptions. Other inspection elements required (for example in the context of the F-Gas regulation) will also be considered. The procedure also indicates the time taken for every step of the inspection as a basis for the "time cost: energy benefit" analysis.

Finally, the 12-year inspection is an audit involving the detailed inspection of an A/C system which the inspection has indicated has an unacceptable performance in one or more areas. This may involve more specialised checks that will usually be outside the competencies of an inspector. The main aim is to identify where the problems are within the system so that the system owner can commission a specialist to rectify the problems.

Within the building, the cooling systems are summarized and the overall refrigerating capacity is subject to the mandatory inspections. The annual inspection can be made by service personnel while the 3-year and 12-year inspections must be made by independent experts. Special requirements for A/C inspectors are not yet in place as training will not start until the winter of 2008/2009. The inspection obligations will come into force on 1st January 2009.

Case study 1: Modernisation of a multi-storey apartment house, MAKARTSTRASSE, LINZ

Summary

The existing residential complex built during 1957/ 58 represented a typical problematic tenant building from the second half of the 20th century, but also included additional constraining elements such as heavy traffic and noise.

Figure I.ii - Original multi-storey apartments

The renovated building meets the requirements of a passive house through a prefabricated ventilated GAP solar façade, reinforced insulation of top floor and cellar ceiling, enlargement of existing balconies including parapet insulation, glazing with passive house windows including integrated sun protection, new roofing in as well as controlled room ventilation with single room ventilators. A high level of prefabrication supports the idea of tenant friendly renovation. The total floor area is 3,106 m^2.

Figure I.iii - Multi-storey apartments after renovation

Energy use figure calculated include:

Before renovation: *Constructions [U-values: W/m^{2}K]:*

- outside walls [1.20]
- roof [0.90]
- cellar ceiling [0.70]
- windows [2.50]

Installations
- gas boiler

After renovation: *Constructions [U-values: W/m^{2}K]:*
- outside walls [0.08]
- roof [0.09]
- cellar ceiling [0.21]
- windows [0.86]

Installations
- district heating
- mechanical ventilation with heat recovery for each room

Reduction of energy index from current 179kWh/m^2 to a maximum of 14.4kWh/m^2 living space according to PHPP. This means savings of about 444,000 kWh/a, therefore diminishing of carbon dioxide emission from about 160,000 kg/year to 18,000 kg/year. Heating costs for a flat of 59 m²: € 40.80/month before renovation–after modernisation €4.73/month.

Additional improvement of living quality is made possible through increase of sound protection and good ventilation by means of high quality single room ventilators without opening of windows. In addition to that, use of existing balconies through enlargement, encasing through erection of insulated parapet and side part.

Additional information

- Now, after the renovation, the apartments offer a much higher user comfort, also due to a new lift, the enlargement and glazing of the balconies and the mechanical ventilation with heat recovery for each room.
- An important measure was the switch from gas boiler to district heating which in Linz is partly produced by biomass.
- Three meetings were organized for the tenants, where they were informed about the renovation measures. In the beginning, there were a number of critical voices, as a result of this active information policy, a high acceptance was achieved.

Lessons learned and conclusions

- The building was in need of renovation, the balconies were nearly unusable because of the heavy traffic resulting in dirt and noise exposure.
- It is worthwhile to involve and inform the tenants.
- Due to the pilot character of this project, a significant additional effort was necessary which, however, fully justified by the result.
- New buildings of this housing association will be equipped with mechanical ventilation from now on.

Figure I.iv – Balconies at the renovated apartments

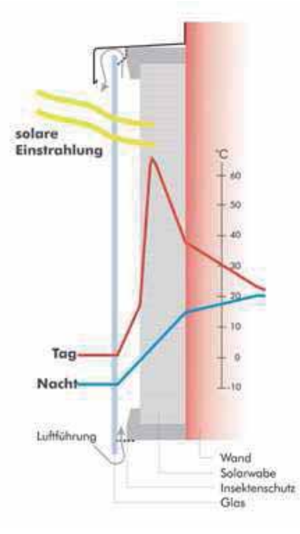

Figure I.v - "GAP-solar façade" Technical detail

Objectives and Results

The main reasons for the renovation were complaints by tenants regarding poor usability of the balconies because of the heavy increase of traffic on the street below. Additionally, the building was due for general improvements. High energy costs and the wish to do a pilot project to collect experience for other projects also were part of the motivation.

Now, after the renovation, the tenants are very happy about their new living quality. For example, a tenant was suffering from a dust allergy. She reported that after the renovation and installation of the mechanical ventilation, the symptoms have disappeared and she does not have difficulties in breathing any longer.

Case study 2: The Christophorus House - A multi purpose office building with low energy consumption

Introduction

The start of construction was in December 2002 for a multi-purpose office building with low energy consumption for BBM in Stadtl-Paura, Upper Austria. BBM stands for (Beschaffungsbetrieb der MIVA) a non-profit organisation to organise the supply for a developing countries agency. Its main focus lies in ecological water and energy supply. This ideological background was the motivation for an innovative and ecological optimised concept for a new building for 40 employees. Due to early involvement of a planning team (architects, wood-builders, energy-specialists) the decision was made for a multi-purpose office building with storage, retail stores and community service in low energy standard.

Figure I.vi-Multi purpose building in Stadtl-Paura

The minimum parameters to meet the standard of a "passive office building" were set by the Institute for "Passive House" in Darmstadt. The final (measured) figures proved to be even better due to careful planning by the leading architects Albert P. Böhm and Helmut Frohnwieser.

Passive house standard

The Passive house standards to be followed included:

- Buildings below 15 kWh/m^2 year,
- Heating Energy Figure at 14 kWh/m²a,
- Pressure-test-air-change figure: n50 0.4 h^{-1}
- Primary Energy Figure: 49 kWh/m² (including power supply for total house-supply).

Architecture and Construction Principles

The specification of the site resulted in a circular building form that is divided by regular cubic shape to open up the building. The split into two separate main volumes represents the different functions. The main volume is four stories high and the centre is a glass dome covering the open atrium for all floors and brings down the light to the first floor. This serves also as the entrance to the community centre for 100 people. The storage sector is a separate volume located in the south of the core building including packaging and truck-parking. The core contribution to reach the goals of a "passive-house" standard is through the use of an innovative wood construction system. The round shape of the building put an extra task to the wood engineers to prevent heat losses. The main structure is wooden frame. The covering walls are not caring weight. Due to the round shape and its optimised day light use it was possible to have deeper office spaces than in a regular shape. The following aspects position this office building as a prototype in the wood building industry:

- Curved outer walls in "passive house" standard done as prefabricated elements,
- The building load of 4 stories of an office building are carried by a wood structure,
- Round columns made out of assorted natural rounded trunks instead of expensive and energy consummating Multi-Layer wood,
- The weight of the floors is brought into the wooden structure without steel-connectors.

Energy concept

Buildings for housing use most of their energy for heating. Office buildings use their main energy for light, air-conditioning and computers. The energy consumption is driven by mainly by two factors:

- the quality of computers and copy machines;
- user comfort in the office building such as temperature, day-light, light and quality of air.

This results in the fact that cooling of an office building can be more energy consuming than heating. Therefore a different concept for low energy consumption is needed. With the help of energy specialist over the whole planning process the dynamic modelling and simulation was done in TRNSYS. This proved to be influential to architecture, construction method and detailing.

Heating and cooling energy consumption for the whole building [kWh/a]

Due to dynamic simulation models the team was successful in achieving parameters of 15 kWh/m²a and even below for the Heating Energy Figure and Primary Energy Figure for cooling of 49 kWh/m²a (maximum 80kWh/m²a). The solution for the heating was a heating pump with earth collectors combined with a highly efficient air supply system including heat recycling. For cooling in summer the system with earth collectors works reverse. The power supply for the heating pump is compensated with an 80 m² photovoltaic feature.

Recycling of Water

1. The building has a water basin for collecting the rain water. To maintain the quality of the water a circulation pump is used to bring the water to a biological sand filter with plants.

2. Rainwater collector: In case of rainfall the overflow of water from both building roofs will be guide over the sand filter to tank. If the maximum level is reached, the water goes into a drainage pit.

3. Gray Water: The water from the kitchen and the snack bar is collected separately and stored in a grey water tank. A timer brings this water to planted filter basins, and from there runs to the rain water collector.

4. Rainwater use: From the drain water pit a pump system brings the water to toilets, waters plants, if there is not enough grey water. The system for the toilets includes a water watch for exact public fees for water use.

The building with its 2000 m² was finished in October 2003. Exact monitoring will help to ensure the quality and to further exchange the knowledge gain in that experiment.

Achievements

- The Heat Energy figure is 14 kWh/m²a
- Pressure-test-air-change figure: n50 0.4 h^{-1}
- The Primary Energy Figure is 49 kWh/m²a

Lessons Learnt

- A holistic approach is beneficial to the project;
- A careful simulation of the dynamic building ventilation is a key element for success;
- Cooling of office building is an crucial factor;
- The complexity of the task demands a good interaction of involved specialists.

Urban case study: Solar City, Linz

The original comprehensive master plan for 5000 inhabitants was done in 1992 by the Austrian architect Roland Rainer. The first step of realisation was complete in 1994, including the formulation of the READ group (Renewable Energies in Architecture and Design) with the partnership of Norman Foster/GB, Richard Rogers/GB and Thomas Herzog/D and the energy planer Norbert Kaiser/D, and sponsored also by the European Commission DG XII. In 1995, 1300 apartments on 32 hectare land was foreseen and in 1996 the Architect Martin Treberspurg/A, a specialist on solar architecture was also responsible for additional area. The project was also supported by landscape architects and sociologist, such as the Wohnbund Salzburg. The building phase lasted from 1999 up to 2008, and the first apartments were finished in 2003. The area is situated along the river Danube and is ecological sensible. Therefore the new settlement was considered to cover the aspect of recreational facilities and recultivation of a small river and a lake. It also has a concept for grey water use.

Figure I.vii – Layout masterplan of solar city

Solar Energy

The name originates from the European Charta for solar energy in architecture and urban planning from 1996. This includes the basic orientation of buildings and its height, the quality of the building envelope as well as the use of active and passive use of solar energy. The concept of low energy was introduced by combination of technical details, good ration of volume to square metres and orientation of building blocks.

In the Solar City a wide variation of typology was used. It ranges from east-west oriented rather wide building blocks including large scale windows to south oriented houses with 6m high winter glass houses to passive house standard buildings in different variations. It is meant to create a mix of various attitudes in the spirit of solar building concepts.

Landmark and subsidies

The initial plan was to have a European-wide showcase of district planning including alternative use of energy. The start for realisation was also based on an agreement of the 12 social housing companies involved to have common standards in energy figures such as hot water solar panels and prime energy figure of below 44 kWh/m^2a. This was also applied to public buildings such as schools, kindergartens and similar facilities. The basic idea was to provide at least 34% of hot water by solar panels. Reality shows a figure almost close to 50 % and the average figure of energy/building below 36 kWh/m^2a. The goal was also supported by subsidies by the municipality of Linz and resulted in a total of 3500 m^2 of solar panels mounted on roofs. The problem of overheating in summer was already considered in the planning phase and every social housing company involved had to prove by calculation to stay below the problematic temperature.

District heating

Energy supply for all buildings is done by a district heating supply system. It contains pipes of 150 mm in diameter and is linked to the overall district heating system of Linz. The transport pipes of steel are specially insulated with polyurethane foam resulting in a loss of only 8% from heat generation to end-user.

Energy supply

The district heating system was completed in 2004 with a 65m high storage-tower for a total of 35,000 m^3. The system was also combined with a biomass-heating/energy plant. This results in an efficiency of heating material of 85 % by the use of a so called “Kraft-Wärme-Kopplung”. It provides a total of 17 % of the energy needed in the district heating system being also a relevant factor for CO_2 reduction.

Monitoring

In the framework of “house of the future”, a governmental research activity of Austria, there was the idea to have a net-based assessment tool for municipalities for big urban developments in respect to sustainability, social aspects as well as mobility and energy matters. This tool was used in 2005 for a sustainability check.

Infrastructure

The centre of the solar city is a square with facilities such as banks, grocery store, coffee shop, a church and also an urban office dealing with social matters of inhabitants. Schools, and also a high education facility (Gymnasium) are in place. Close to the centre in the north is a recreational facility. A public tram was opened in 2005 to link the solar city by public transport to the city centre of Linz in half an hour. The individual transport remains with a point to point situation due to its geographic situation and creates traffic problems during rush hours. In 1999 solar city concept was nominated for the Environmental Award 2001 by the Earth Society Foundation, New York.

National conclusions

Austria is trying to reduce energy consumption as far as possible, knowing that dependency will become expensive and growing energy demand will not be covered by renewable energies, even if it were possible to double the share of renewable energy use. Thus, a system of continuous strengthening of the given requirements has been introduced which should finally lead to a reduction of more than 70 % of the energy demand for heating and cooling in the residential sector. Subsidising systems have already been adapted to accommodate this.

Since these ambitious goals need both experts and craftsmen with high qualifications, training has been organised for them. The nine counties have produced a complex training system consisting of different modules (i.e. heating systems, cooling and aeration, calculation, building management, information etc.) which is used as a very efficient instrument to achieve the qualifications. A considerable part of it can be done via e-learning thus giving experts the opportunity to profit from the training without being forced to spend too much time during working day. Quality management of the issue of certificates is being established by the county authorities who work closely together with civil engineers and the Chamber of Commerce (representing professionals and craftsmen). Quality management will help those people who are authorized by law but not sufficiently technically qualified by analyzing, and correcting, if necessary, a random sample of certificates. Actual Austrian legislation does not provide for fines or punishment, but the national legislation for authorized experts allows action for liability. Issuing an incorrect building certificate can lead to large compensation claims. An important part of the quality management is a database for all Austrian building certificates which will be in place in August 2008, giving a complete overview of the certificates and allowing decisions on energy related policy which had not been possible up to now because of the lack of detailed data. This database will contain almost all the data needed for the calculation of energy certificates (including heating and HVAC systems).

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Plan and pictures:
Courtesy to Arch+More ZT GmbH / Arch DI Ingrid Domenig-Meisinger /Linz / Haseneck 7 4048 Puchenau and Architect DI Albert P. Böhm A-4020 Linz, Stelzhamerstraße 10,
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II Belgium

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National context

Belgium is located in the north western part of the European continent. The surface area of Belgium is 30,528 km^2. The main natural border is the North Sea on approximately 60 km. The altitude is slightly increasing from the western coastal region, which is a part of the Great Plain of Northern Europe, to the highlands of the Ardenne massif in the eastern part of the country which culminates at 694 m in an area called Hautes Fagnes and located near the German border. Belgium is a federal country (constitutional monarchy) organized in three regions (Flanders, Wallonia and Brussels Capital Region). The official languages are Dutch, French and German.

Climate

The Belgian climate is known as being oceanic and positively influenced by the Gulf Stream [1]. Winters are mild and summers are cool. This is particularly true for the western and central parts of the country. Due to its distance from the sea, to its altitude (the Ardenne massif is the first natural barrier for humid air streams coming from the ocean) eastern Belgium is characterized by cold winters and rainy summers. Belgium is located at the average latitude of the northern hemisphere.

	Central Belgium: Brussels	Eastern Belgium	Western Belgium: Coastal region
Average temperature in January (°C)	2.5	-2.1	2.9
Average temperature in July (°C)	17.2	13.6	16.1
Rainfall (mm)	821	1326	687

Table II.i: Average temperatures and rainfall for different regions in Belgium [1]

For that reason, the weather is mainly influenced by the location of the separation line between subtropical and polar air streams. This moving front across the country leads to complicated atmospheric situations and unstable weather conditions. During a climatic year, it is common to observe periods of non regular conditions. As an example, the highest temperature ever registered in Belgium is around 40°C, the lowest one is -30°C.

Demographics

In 2008, the estimated population of Belgium was 10,666,866 inhabitants (2001 census: 10,296,350 inhabitants); leading to a density of 349 inhabitants/km^2 (one of the highest in Europe after the Netherlands and some urban states). The demographic growth rate is 0.2%. 97% of the population live in the cities and their suburbs. 9% of the population are foreigners (mainly from the European Union). The main age category is 40-44 years old (23% below 20 years old, 60% between 20 and 65 years old, 17% older than 65 years old). The life expectancy was (2003) 75.85 years for men and 81.69 years for women. The literacy rate is 99% [2].

Economic features

In 2007, the GDP of Belgium was €330 billion (€30,500 GDP per capita). Industry accounts for 24.5 % (engineering and metal products, motor vehicle assembly, transportation equipment, scientific instruments, processed food and beverages, chemicals, basic metals, textiles, glass, petroleum) whereas services and agriculture account respectively for 74.2 % and 1.3 %. In 2007, the unemployment rate was 7.5 % and the economic growth was 2.7%. Belgium is one of the ten largest trading countries in the world and the leading country in terms of exportation per capita. Its high level of economic performance is due to its dense transportation network and to the high productivity of its manpower. The central position of Belgium at the crossroad of the different cultures of Western Europe

(Celtic, Roman, Germanic, French, Dutch, Spanish, and Austrian) makes its people at ease with international relationships and trading. The Belgian economy is completely open. It is based on some major foreign companies which make the Belgian economy very sensitive to external decisions but also on an important network of innovative SMEs. Important differences exist, in terms of economical performances and unemployment rate, between the different regions of the country. During the second part of the twentieth century, the traditional walloon industry knew an important decline whereas Flanders was developing. Since the beginning of the year 2000, these differences slightly decrease due to the structural development of new sectors in Wallonia (biotechnology, communication and image technology, logistics, materials technology, aeronautics) [3, 4].

Energy in Belgium

In 2006, the final energy consumption of Belgium was 43.0 Mtoe for a primary energy consumption equal to 59.4 Mtoe. Belgium has one of the highest levels of primary energy consumption per capita in Western Europe [2, 5]. This is namely due to poor insulation level of buildings (residential consumption accounts for 33% of the total final energy consumption) and to the important contribution of some industrial sectors (metal industry). Since the 1973 oil crisis, the part of oil products in the primary energy consumption has been decreasing (it was 60% in 1973) thanks to the development of the nuclear programme (55% of the electricity production) and to the growing contribution of natural gas (2.3% per year).

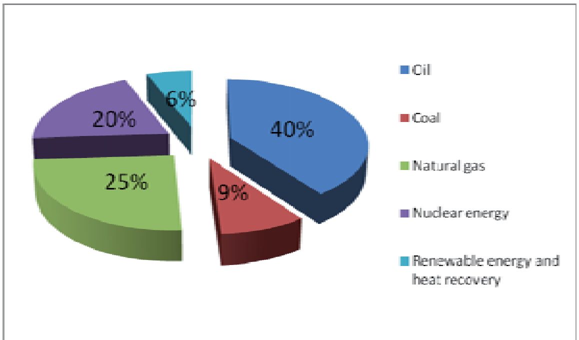

Figure II.i - Primary Energy consumption in Belgium: percentage by source (2006)

The energy intensity factor (on primary energy basis) has been continuously decreasing since the late nineties (20% reduction compared to 1980) whereas the GDP was increasing (raise of 60% compared to 1980).

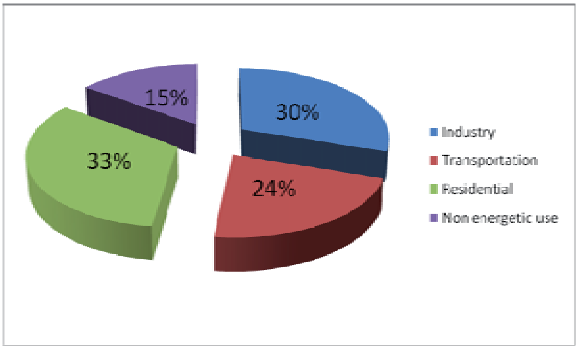

Figure II.ii - Final Energy consumption in Belgium:percentage by sector (2006)

The decoupling of the energy demand and of the GDP is mainly due to important investments in the industrial sector and to the growing part of services in the economy. The Belgian federal office for planning forecasts that this decoupling will lead to a sustainable decrease of the primary energy consumption of the country starting in the year 2010 [6]. The final consumption will continue to increase during the next decades (10% during the period 2000-2030). The main challenge for Belgium will be to fulfil its international engagements in terms of CO_2 emissions in a context of denuclearisation of its electricity production park. The part of renewable energies in the Belgian energy profile was still very low ten years ago. This situation was mainly due to the low potential of the country in terms of high power production (for electricity) which is a serious drawback in a country that is culturally attached to centralized energy production systems. The situation is evolving quickly. Since the beginning of the years 2000, wind energy has known an important development in Wallonia. In 2007, the Belgian installed capacity was nearly 300 MW (the maximum demand is approximately 13,800 MW). Important programmes, namely high power off-shore installations, are under progress. In 2030, the electricity production by wind power should reach 6,000 GWh (for a total production equal to 112,000 GWh; 6%). This should represent half of the total renewable production of electricity (12%); the other important source is biomass.

GHG emissions

In 2006, the total GHG emissions of Belgium were 137 Mt of CO_2 equivalent (EEA, 2007). The baseline emission level (1990) is 145.7 Mt of CO_2 equivalent. The reduction rate attributed to Belgium is 7.5%. The target value is thus 134.8 Mt. According to Belgium's projections, the emissions level in 2010 will be 4% below the base year level so that the target will be reached by making use of Kyoto mechanisms [7].

EPBD regulation

Calculation method

The EPBD regulation is based on the E-level criteria. The E-level is defined as the ratio between the primary energy consumed by a building (E_{prim}) and the primary energy which would be consumed by the same building if it would have been built before the EPBD regulation came into force ($E_{prim\ ref}$). An E-level equal to 100% thus means that the building just respects the previous regulations. E_{prim} takes into account:

- the heat demand for space heating;
- the heat demand for domestic hot water production;
- the cold demand;
- the energy consumption of auxiliaries (circulation pumps, fans);
- the regulation, distribution and storage efficiencies of the heat distribution and storage systems;
- the efficiency of the energy production systems (heating and cooling);
- the primary energy ratio (for example for electricity);
- the use of renewable energies.

Minimum requirements [Refs 8-10]

New buildings

For residential buildings, office, service buildings and schools, the minimum requirements are E100 (corresponding to a primary energy consumption equal to 170 kWh/m^2) and maximum U-values (set for the different kinds of walls). Ventilation requirements are also included in the regulation as well as overheating risks. For new buildings with a surface area higher than 1000 m^2, a feasibility study should be achieved in order to identify the best technological choice for energy production.

In 2011 (2010 for Flanders), the maximum allowable E value will be E80 (primary energy consumption equal to 130 kWh/m^2).

In case of extension, the building may be submitted to the minimum requirements for new buildings. The same requirements are set for existing buildings with a surface area higher than 1000 m^2 concerned by an important refurbishment procedure (minimum 75% of the envelope + energy production systems)

Existing buildings

Maximum U-values and ventilation requirements must be fulfilled in case of renovation.

Energy performance certificates

The energy performance certificate contains information about the energy consumption based on the calculation method. Proposals for improving the energy performances are also included taking into account the economic aspects. The certificate is mandatory for new buildings and for existing buildings when they are sold or leased. In public buildings (public services or buildings occupied by public authorities – surface area higher than 1000 m^2); the certificate must be displayed. The certification procedure came into force in 2009 (1/1/2009 for Flanders, 1/9/2009 in Wallonia).

Building regulation

The building regulation is a regional competence in Belgium. Flanders, Wallonia and Brussels Capital Region have their own EPBD regulations. A unique EPBD calculation method was adopted by the three Regions except for the calculation of the reference primary energy consumption which is slightly different from one region to another (adapted to the reference built environment). The administrative procedure and the name given to the different actors are also somewhat different. The minimum requirements (E level) are in the same order of magnitude. The Regions actively collaborate to improve the existing calculation method in order to adapt it to new technologies (for energy production) and to new architectural practices. These studies mainly involve the universities from the whole country and the Belgian Building Research Institute.

On the administration point of view, the EPBD regulation is dealt with by the communal authorities: the EPBD declaration should be introduced by the applicant together with the building permit application.

Other initiatives

Important tools have been developed to accelerate the transition towards very low energy buildings and to strengthen the use of renewable energies. Subsidies (regional level) and tax reduction (federal level) may be obtained for the following actions and investments:

- Energy audit in existing buildings
- Insulation level improvement in existing buildings

- Heat recovery on ventilation systems
- Heat production using biomass
- Low temperature boiler
- Regulation for heat distribution systems
- Combined heat and power systems
- Heat pumps
- Thermal solar collectors
- Photovoltaic panels

In Wallonia the "eco-prêt" initiative has just been launched. It allows people to access a 0 % bank loan for investment in insulation or efficient energy production systems.

It appears that the different financial supports have a positive impact on the energy performance of new buildings. A majority of new buildings are labelled E80 whereas the actual regulation sets E100 as a minimum requirement. Reaching E values between E60 and E80 seems to be a good economical target. Subsidies, tax reduction and other kinds of incentives lead to an anticipation of future minimum requirements in terms of energy performance.

The move towards a better energy efficiency of the built environment is also driven by important information campaigns and specialized education programmes.

Case study 1: Energy performance of a single-family dwelling

Introduction

This study case presents the energy performance of a single-family house built in the Belgian countryside, located in Leuze, Province of Namur, central Belgium. The architectural concept is simple and representative of the "fermette" style (farmhouse style). The originality of the project relies on the following points:

- global insulation level is higher than the one required by the existing regulation;
- project includes all the common technologies that can be used in housings to lead to energy savings and renewable energy exploitation (heat recovery on ventilation, solar collectors for domestic hot water production, heat pump for space heating);
- heat pump is a prototype of static air to water installation;
- space heating installation was monitored and the real energy performance of the building was determined and compare to the calculated one using the Belgian EPBD calculation method.

Figure II.iii - Typical single-family house in the Belgian countryside

The building

The house has a wooden frame leading to a low inertial thermal behaviour. The composition of the main walls is provided in Tables II.ii to II.v.

Walls	Thickness (cm)	Thermal conductivity (W/mK)	Global heat transfer coefficient (W/m^2K)
Brick siding	9	0.400	0.26
Air space	4		
Wood panel	2	0.120	
Insulation	14	0.045	
Plaster	2		

Table II.ii - Wall characteristics

Main roof	Thickness (cm)	Thermal conductivity (W/mK)	Global heat transfer coefficient (W/m^2K)
Tiles	12	0.340	0.25
Air space	6		
Insulation	16	0.045	
Plaster	2		

Table II.iii - Main roof characteristics

Flat roof	Thickness (cm)	Thermal conductivity (W/mK)	Global heat transfer coefficient (W/m^2K)
Asphalt layer	1	0.230	0.24
Air space	4		
Wood panel	2	0.120	
Insulation	16	0.045	
Plaster	2		

Table II.iv - Flat roof characteristics

Floor	Thickness (cm)	Thermal conductivity (W/mK)	Global heat transfer coefficient (W/m²K)
Slabs	15	1.000	0.41
Insulating slab	3	0.100	
Insulation	6	0.035	
Slab	6	0.840	
Tiles	1	0.810	

Table II.v - Floor characteristics

The windows have an average heat transfer coefficient equal to 1.49 W/m^2K for a total area equal to 22.9 m^2. The protected volume is 439 m^3 for a heated floor area of 177.05 m^2. The heat loss surface area is equal to 386.7 m^2. The global heat loss coefficients (transmission and ventilation) are respectively equal to 147 W/K and 259 W/K (without taking into account the heat recovery and considering a ventilation ratio equal to 0.62 h^{-1}).

Equipment

The building is equipped with a mechanical air extraction system (ventilation) with heat recovery on exhaust air (275 $m^3\ h^{-1}$, heat recovery efficiency: 0.9). The production of domestic hot water is ensured by a solar system (solar collector: 5 m^2; optical efficiency: 0.83; heat loss coefficient: 3.36 W/m^2K). 65% of the hot water is produced by the solar system; the remaining 35% are produced by an electrical back-up system.

The heat for space heating is produced by a brine-to-water heat pump (Figure II.iv). The brine circulating in the evaporator (brazed plate heat exchanger) is heated back in a static air heat exchanger. The static air heat exchanger consists of longitudinally finned tubes in which heat is transferred from the ambient air to an ethylene glycol-water mixture flowing inside the tubes. The exchanger consists of six units of about 1 m wide and 1.4 m high connected in parallel. The heat exchanger is located in the garden along the hedge. It is oriented at 30° west from the south and located in an open space without shading. The heat transfer is mainly due to wind convection (no fan). One of the main characteristics of such systems is that frost formation is minimized; no defrosting system is required. On the hot sink side, the condenser is also a brazed plate heat exchanger. In this exchanger, water is heated; an electrical heater, located downward the condenser in the water loop can be used in case of low outdoor temperature (below the balance point). The "hot water" then flows through the heat distribution system (heating floor + convector heater on the first floor). The compressor (variable speed) is of scroll type. The refrigerant is R404A. The whole system is presented in Figure II.iv.

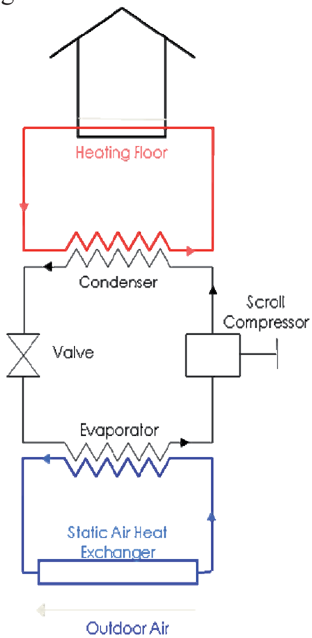

Figure II.iv - Brine to water heat pump using air as source

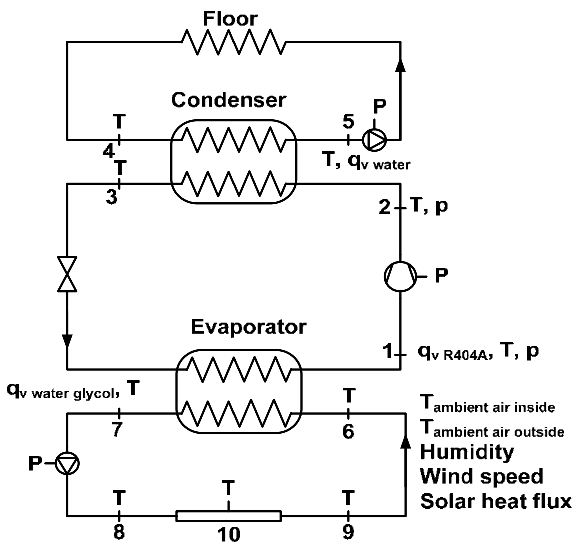

Figure II.v - Measurement points and data (T: temperature, p: pressure, P: power, qv: volume flow rate)

Instrumentation

The whole system (heat pump) was instrumented in such a way that it was possible to determine the heat flow produced at the condenser, the electrical power (compressor, circulation pumps, electrical back up) and the coefficient of performance of the installation (COP). The measurement points and data are presented in Figure II.x. The measurements are performed every second; average values are provided every minute by the data acquisition system. The data are transferred every week by modem and are treated by calculation software which provides daily, monthly and yearly analysis. The monitoring period was November 2005 to May 2007. During the first heating period, the compressor was working at fixed speed. During the second one, the compressor capacity was adapted to the heat demand.

Simulation

The dynamic thermal behavior of the building and its heat production and distribution system were simulated using a homemade software (monozone; simulation step: 1 minute). The energy performances of the whole system were also evaluated using the Belgian EPBD calculation method.

Results

Figure II.vi presents the experimental values of the COP as a function of outdoor temperature. Each point represents a daily average.

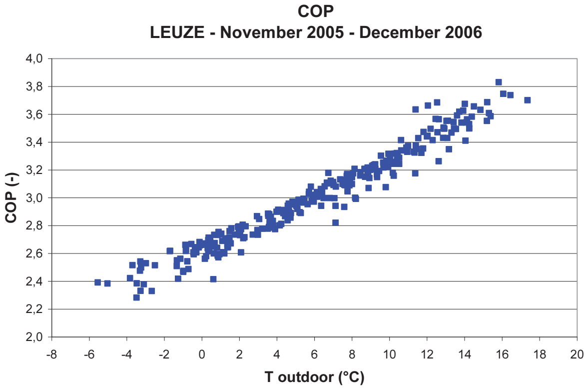

Figure II.vi - Daily COP as a function of outdoor temperature; constant speed working

Figures II.vii and II.viii present the experimental and simulated (dynamic model) values of the heat demand and the COP for each month of the December 2005-December 2006 period. The global results for the heating period are given in Table II.vi.

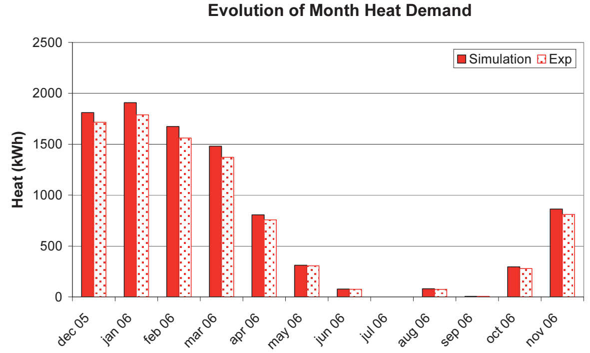

Figure II.vii - Heat demand – comparison between simulation and experiment

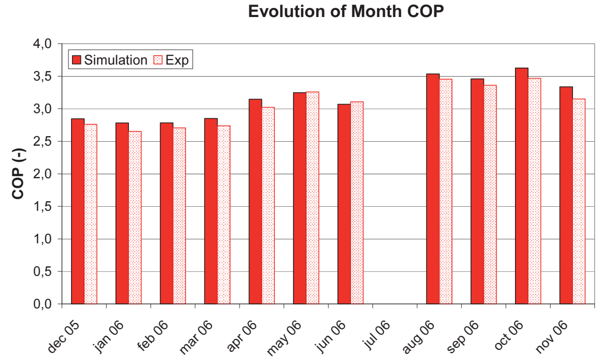

Figure II.vii - COP – comparison between simulation and experiment

During the second heating period (1/9/2007 – 31/5/2008); the capacity control of the compressor was activated. The average COP rose to 3.28 which represents a reduction of the primary energy consumption equal to 31% when the installation is compared to a fuel boiler (efficiency: 0.9). The quantity of CO_2 released is reduced by 25% (neglecting the nuclear contribution in the electricity production). This reduction reached 68% if the nuclear contribution is taken into account in the electricity consumption.

	Heat (kWh)	COP	Electricity (kWh)	Primary energy (kWh)
Experiment	8743	2.82	3103	7756
Simulation	9312	2.92	3185	7963

Table II.v – Global results for the heating period

The E-level determined by the EPBD calculation method is E40. The primary energy consumption of the building is thus 60% lower than minimum required by the EPBD regulation.

The over-investment due to improved energy efficiency (comparison to the investment for an E100 building) was estimated to €20,386 (tax reduction and subsidies included). The resulting pay-back time is 13 years.

Case study 2: Energy performance in Social Housings: the Zoerle-Parwijs project

Introduction

The 2007 enquiry (Federal Public Services – Economy) on household budget showed that the housing costs (rental costs, energy costs) represent 33% of the total budget of a family living under the welfare level in Belgium (14% of the population). This part is only 24% for the rest of the population. The net income per month corresponding to the welfare level is estimated to €822 for single people and €1726 for a two-child family. High energy costs, as those we knew during the first semester of 2008, lead to dramatic situations for low income people as they must compensate the higher budget ratio devoted to energy by reducing the expenditures in food, health care and education. This leads to political debates on the way to strengthen the purchasing power of low income people. It is obvious that providing low rental costs housings with low energy demand appears to be the best solution. New pilot projects were developed in the social housings sector aiming at reducing the negative social impact of high energy prices.

The Zoerle-Parwijs project [11]

Zoerle-Parwijs is a district of the City of Westerlo located in Northern Belgium (province of Antwerp - Flanders). The social housing society Zonnige Kempen developed a project of 13 social dwellings (10 houses and 3 flats).

Figure II.ix -The Zoerle-Parwijs social housing project

This project combined low energy demand buildings and a complex energy production system based on renewable energies. It includes:

- a heat pump (thermal power: 45 kW);
- thermal solar collectors (75 m^2);
- a gas boiler;
- vertical borehole heat exchangers (60 boreholes; 40 m depth);
- Photovoltaic panels (installed power: 10 kWp);
- an asphalt solar collector (heat exchanger located under the asphalt area:500 m^2);
- heat recovery system on ventilation;
- ventilation air pre-heating (heat recovery on the photovoltaic panels and ground heat exchanger).

The heat pump is used for space heating and as the first backup system for hot water production: the main energy source is the ground. The thermal solar collectors are used for hot water production; during the summer time, extra heat is stored in the ground using the vertical borehole heat exchangers. It is also possible to use the thermal solar collectors connected to the heat pump for space heating. The heat produced by the asphalt collector is stored in the ground. The gas boiler is used for peak demand (space heating and hot water production). The electricity demand for ventilation is produced by the photovoltaic panels.

The energy production system is being monitored in order to validate the energy performance determined thanks to simulation studies. The total heat demand was evaluated to 97,275 kWh per year (27,345 kWh for domestic hot water production and 69,930 kWh for space heating). The thermal solar collectors and the asphalt collector should produce respectively 22,210 kWh and 76,930 kWh per year. The heat pump electricity consumption is estimated to 22,750 kWh whereas 10,635 kWh should be produced by the gas boiler. 66% of the heat demand should then be covered by renewable energies; 34 % of the solar energy is lost during storage.

The primary energy consumption (heat production) is 68,692 kWh per year (considering an efficiency of 0.4 for the electricity production and a boiler efficiency equal to 0.9). Using a boiler for heat production would require 108,083 kWh. The primary energy saving is 36%.

Conclusions

Reducing the energy consumption of the built environment is of first importance. This is especially true for Belgium as the Belgian houses and buildings are characterised by poor energy performances. This situation results from a long period of low energy costs (for fossil fuels) and rather high incomes. Moreover, the architectural and construction practices as well as the building plots prices led to high investments costs. These unfavorable conditions prevented from further initial investments to improve the energy efficiency of the built environment.

The growing awareness of the necessity to evolve towards a sustainable society and the instability of the energy prices which leads to a new social fracture are responsible for big changes in building practices, energy management and political actions. These major changes were driven by the EPBD regulation.

It appears that the minimum requirements set by the Belgian EPBD regulation are still low compared to other European countries. Subsidies and tax reductions seem to be additional measures which have a benefit effect on the real energy performance of new buildings. They make possible over-investments (short pay-back times) leading to a primary energy consumption reduced by 20 to 40% when compared to the minimum requirements. This discrepancy between what is mandatory and what is possible on an economic point of view creates a kind of competition spirit in the building sector which is positive and supported by important education training programs and information campaigns.

As shown in the two study cases, the use of combined systems for energy production (based on well known technologies) may lead to very low primary energy consumptions. The initial cost of such systems is quite high; resulting in long pay-back time. On the energy point of view, their use should be supported but the priority must be given to lower the energy demand.

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III Cyprus

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National context

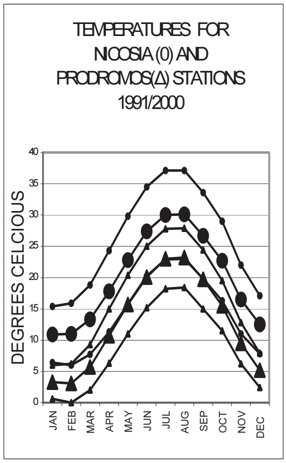
Cyprus is a very small country, covering only 9,251 km^2. It is the third largest island in the Mediterranean after Sicily and Sardinia. The island gained its independence in 1960 and was proclaimed a Republic. At the period 1960-73 Cyprus went through a fast and almost uninterrupted growth. Despite the breakdown, in the years 1974-75, due to the Turkish invasion and the occupation of 38% of its territory by military forces, the economy recovered soon after and a substantial growth has been achieved. From 1975-1993, Cyprus once again witnessed additional economic growth, accompanied by an expansion of social services. Today the people of Cyprus, who live in the Government controlled part of the country, enjoy a high level of education, low unemployment and a good standard of health care. Crime is maintained at low levels. 69% of the population lives in urban areas, which cover 9.6% of the island. By 1st May 2004, Cyprus became a full member-state of European Union.

Climate

Cyprus shares an intense Mediterranean climate with extended hot, dry summers and rainy rather changeable winters, which are separated by short autumn and spring seasons. Rainfalls vary a lot. The average annual total precipitation is about 500 mm. Months of the heating period duration (<20°C) are 6-8 and the cooling duration period (>24°C) are 2-4 with the highest period being the mountainous area (Figure III.i).

Demographics

The Statistical Service of Cyprus provides basic demographic data approximately every 10 years. The last two census of population were carried out in 1992 and 2001 (Figure III.ii). The total number of persons enumerated in 2001, in the area controlled by the Cyprus Government, was 689,565. The increase of the dwelling stock is shown in Graph 3. The total number of units was 286,000 in 2000. Almost 85,000 of these units were built in the period from 1960-1980.



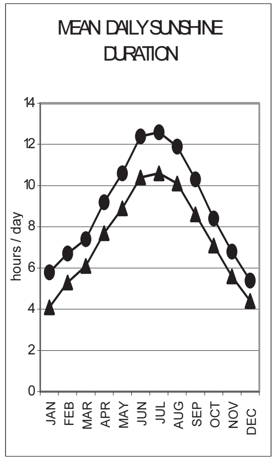


Figure III.i - Basic Meteorological data of Cyprus

Out of the total number of units, nearly 60,000 are apartment blocks and 125,000 are detached or semidetached houses. The number of new dwellings completed over the last 15 years (Graph 4), 5,000 dwellings in 2000, the average dwelling area (Graph 5), 189 m^2 for 2000 and the average construction cost in Cyprus Pounds (1CyP=1.71Euro) in Graph €6, 568 per m^2 for 2000. From the above data it can be derived that the average number of persons per dwelling, was 3.23 for 1992 and 3.06 for 2001. In addition to that the number of square meters per person, was 49.5 for 1992 and 61 for 2001. Basic economic data according to Statistical Service, stipulate that in 2000 the Cyprus economy registered a growth rate of 5%, unemployment rate less than 3.3%, inflation of 4.1 % and fiscal deficit of 3.5%. The per capita income was more than €12,825 for 2000.

Carbon dioxide emissions

Data was collected for carbon dioxide emissions per capita from 1990 (6.8 metric tons) through 2004 (8.2 metric tons) showing an increase of 1.4 metric tones. Cyprus is 47 on the rank as ranked by their metric tons of carbon dioxide emissions per capita in 2004. Total CO_2 Emissions for 1998 is 5918 thousand metric tons divided into Solid fuels (70), Liquid fuels (5251) and Cement manufacturing (598).

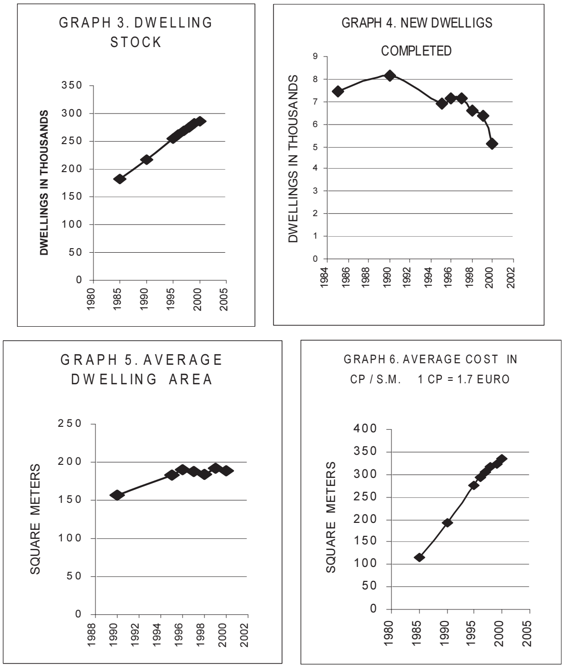


Figure III.ii - Demographic and Housing data

There is a 27% change since 1990. Total CO_2 Emissions by Sector for 1999 is 7 million metric tons divided into public electricity, heat production, and auto producers, manufacturing industries and construction, transportation, residential; other sectors (Includes the commercial sector, agriculture, the public service sector).

Energy in Cyprus

At year 2004 the cost of imports of energy amounted to 12% of total imports that is translated to 544 million Euros. With the exception of solar and wind energy, Cyprus has no other energy resources of its own and has to rely heavily on fossil fuel imports. The energy consumption is predominantly oil based. The contribution of solar energy to meet the primary energy needs of the country is estimated to be 5.9% (Figure III.iii). Thus, more than 94% of the total primary energy is supplied by imports. The cost of imported energy represents 63% of the domestic exports. Due to the developmental nature of the economy of Cyprus energy consumption is increasing at an average annual rate, for the last ten years, at about 6.9%.

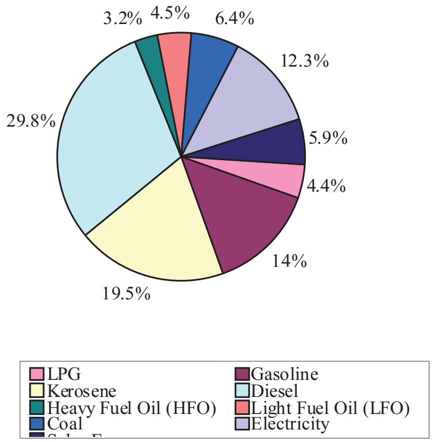


Figure III.iii - Breakdown of final energy consumption to sectors of economic activity

The total annual energy consumption (electricity included by the domestic sector) in Cyprus comprises of 15.1%. It may be remarked that the generation of electricity accounts for 36% of the total energy requirements. Based on consumption by households, a rate of growth of 4.6% is indicated yearly. Breakdown of residential energy consumption in terms of final energy used shows its large share of electricity consumption. In terms of end-use of energy in households, water heating holds the highest place being half of the total consumption, and more than half of the electricity (Figure III.iv).

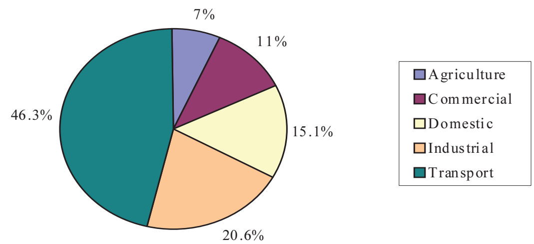


Figure III.iv - Breakdown of final energy consumption to sectors of economic activity

Building regulations

Administrative structure

Cyprus is a presidential parliamentary democracy and administratively is separated into Districts (6 altogether) that are managed by the District Officers appointed by the Government. In addition there are two types of local authorities, the Municipalities (33) and the Communities (352), which are governed by separate laws. Municipalities form the core of the local government structure in urban areas and in tourist centres, whereas Communities constitute the local government structure, in rural areas. Communities with a population of over 5,000 inhabitants or smaller Communities with sufficient economic resources to function properly and independently have the opportunity to become Municipalities. The Mayors and the Municipal Council of the Municipalities, as well as the Presidents and the Community Councils of the Communities, are elected directly by the citizens for a five-year term. The Municipalities and the Communities have their own budget. They are responsible for the construction, maintenance of streets, provision of local services and the appearance of public areas, the protection of public health etc. The main sources of their revenues are state subsidies, taxes and fees.

Development Plans

The planning system is highly centralised. The Minister of the Interior is the Planning Authority and is responsible for the preparation and publication of Development Plans. As such are the "Local Plans" and the detailed "Area Schemes" for the urban areas and the "Policy Statement for the Countryside" for the rural areas. The General Development Plans contain a set of land uses including public facilities and zoning maps as well as policies, provisions and regulations to guide the development. The major advisor to the Minister is the Town Planning Board. The Department of Town Planning and Housing provides technical assistance and expertise.

Authorities responsible for issuing Planning and Building Permits

The Town and Country Planning Law have been enacted, as a whole, on 1st December 1990. The responsibility of issuing Planning Permits rests with ten distinct Planning Authorities, which are the Director of Town Planning and Housing Department, all five Divisional Town Planning Officers in the districts, as well as the four main Municipal Councils of the island. In cases of urban complexes made up of several Municipalities and Community Councils, a new proposal of establishing a joint Planning Authority for the whole conurbation area (covered by each Local Plan) is currently under consideration, by the Ministry of Interior. Building Permits can be issued by the 24 Municipalities (since 9 out of the 33 are under occupation) for the Municipal Areas and the five District Officers, for the rural areas.

Application drawings and inspections

The Law, considering the kind of development, specifies the appropriate drawings and any other documents, certificates etc., which they have to be submitted with the application form to the Planning Authority. Two main issues can be mentioned here:

- There is a legal obligation to submit designs or calculations for thermal, acoustic and fire performance of a conventional building within the application form.
- According to a recent regulation of 2000 all new constructions, renovations and generally any structure, have to be inspected by authorized engineers. Therefore inspections are compulsory for freelance practitioners, though are not compulsory for Responsible Authorities. For this very reason the enforcement of the Planning and Building laws, is not so effective.

Legal framework concerning modifications and improvements

All building modifications require a "building permit" and moreover, the modifications that are regarded as "substantial" require an additional "planning permit" in advance. The specific provision is unclear and therefore depends on the discretion of the respective Town Planning Authorities, to judge whether a modification is substantial or not. The painting of a building for example does not require any permit, simply because is not regarded as a substantial modification. Therefore designers are not obliged to ask for approval of any drawing concerning painting. There are no specific data concerning maintenance, renovations, modifications, etc. of building envelopes. Indicative data however suggest that the average Cyprus family does not pay a lot of attention on these matters, that people extent as long as possible the various works needed and that they proceed to the necessary works, only when the performance of their building is intolerable, or dangerous looking always for the absolute minimum expense. In the vast majority of the cases improvements are related only to the painting of the buildings.

EPBD implementation

The law for EPBD was published by the government of Cyprus on 20th January 2006 as the Draft Final. This law is the Cyprus section of the 2002/91/EK for the energy consumption of the buildings. The date of the implementation of the law will be decided by the parliament of the republic of Cyprus. The date is not specified. The parliament might specify different dates for the implementation of different parts of the law.

- The responsible office for the implementation of the law will be the Director of the department of energy of the ministry of commerce, industry and tourism.
- The energy performance of the building means the quantity of energy that a building consumes or an estimation of the consumption for the different needs of the building that go by the regular use of the building. This could include heating, water heating, cooling, ventilation, and lighting. These are estimate with different values in conjunction with the thermal insulation, the technical specifications and the specifications of the electrical and mechanical fittings, the design and the placement of the building in coordination with the climate, the exposure to the sun and the influence of neighbouring buildings, the energy production from the same building and other factors that influence the energy demand.
- Up to today legislation in regard to the energy needs of buildings does not exist.

Calculation method

The method of calculation of energy output of buildings takes into consideration the following factors: Thermal characteristics of the building (building envelope, internal walls)**,** Installation of heating and catering of hot water (insulations, etc), Installation of air conditioning**,** Ventilation**,** installation of lighting**,** Site and orientation of buildings (exterior climatic conditions), Passive solar systems and solar protection**,** Natural ventilation**,** Internal climatic conditions.

In this calculation will be apprised, individually, the positive effect of the following factors: Active solar systems, other systems of heating and electric systems based on renewable sources of energy, Electric energy produced from RES, Systems of central heating and refrigeration in level of region or building square (district heating and cooling), Natural lighting.

The Minister determines, revises and updates the calculation methodology of the energy efficiency of buildings. The calculation methodology of the energy efficiency of buildings is revised so that it adapts in the technical progress that is carried out in the building manufactures sector and takes into account the relative models that are found in force. The way of presentation of the calculations of the energy efficiency of buildings is not yet specified.

Energy performance requirements

The first formulation of Renewable Energy and Energy Conservation Action Plan was done in 1985 and it was then revised in 1998. Also different other schemes were decided, such as:

- Operation of a first Grants Scheme 1998 (sectors of the manufacturing industry, hotels and agriculture) sectors of the manufacturing industry.
- Following the above was the establishment of The Applied Energy Centre (A.E.C.) and The Cyprus Institute of Energy (C.I.E.), year 2000
- EAC agreed to purchase electricity generated from RES.
- Transmission System Operator (TSO) an independent authority
- Procedures were specified for licensing and interconnecting wind and PV installations to the national grid.
- The formulation of an Action Plan (2002-2010) for RES in Cyprus
- Legislative framework for the promotion of RES and conservation of energy (Apr 2003)
- Cyprus Energy Regulatory Authority (C.E.R.A.) (Jan 2004)
- New grand schemes (Feb 2004)
- New Enhanced Grant Schemes for RES and RUE (Jan 2006)
- Provision of the Legal Framework for the Preparation and Implementation of Schemes for the promotion of RES and RUE.
- Imposition of a levy of €0.22/KWh on all electricity consumed. Proceeds are utilised to finance activities aimed to promote the use of RES and RUE (estimated that more than €72 million will be collected by year 2010)
- The special RES fund is managed by an independent committee (5 members, Permanent Secretary of Ministry of Commerce is the President)

The Plan of Action until 2010 includes:

- The establishment of necessary legislation that allows in the Government the application of programs for promotion of saving of energy and the encouragement of use of Renewable Energy Sources (Law 33 (J) 2003).
- The foundation of Special Fund, the income of which is used exclusively for the financing of activities that aims in the promotion of saving of energy and encouragement of use of renewable energy.
- The Operation of a Sponsoring Plan. By the beginning 2004 was placed in application the

Sponsoring Plan for Saving of Energy and encouragement of use of renewable energy. (2004-2006).
- Five-year plan of action for period 2005 until 2010 for energy saving,
- Compensatory measures for the alleviation of economically low income population from the high energy cost for the winter period November of 2005 - March 2006.

Energy performance certificates

By the of provisions of the roads and building (Energy Performance of Buildings) regulations 2006 and article 8 of the present law, at the manufacture, the sale or the leasing of a building an energy performance certificate (EPC) has to be given either to the renter or the new owner of the building.
- The certificate of the building energy performance includes reports, as being in effect requirements and criteria of comparative evaluation, so that it allows the interested people to compare and evaluate the energy performance;
- The EPC certificate of energy attribution of building is accompanied by constitution for the improvement of the buildings energy performance taking into consideration the economical and financial means;
- The EPC is carried out by independent ways from specialist, which their qualifications are determined by regulations;
- The type and the contents of the EPC, for each category of building, is determined by the Minister;
- The certification for apartments or units that are designed for separate use in building complex's, could be based on a common certificate for the entire building for complex with a communal heating system, or the evaluation of a representative apartment of the same complex.

The Law on Labeling CE that concerns requirements of minimal energy performance of certain appliances of wide use as well as the Law on the Energy Labeling of domestic appliances that has been placed in application from April 2004 and concerns: Refrigerators and freezers, Washing-machines, Tumble dryers of clothes, Dish-washers and Air conditioners, are a step to the right direction.

Inspection of systems

The appropriate authorities which check and implement the law can:
- Enter in any building, or space and check or inspect documents or installations or equipment or space where they are related with the present law and it confiscates any relative documents, goods or samples for which it has legitimate cause to suspect that it might need for proof in relation with offences relative to the present law. It is comprehended that the entry in residence, without the consent of tenant, is allowed only with a legal warrant;
- Ask information from anyone to study, research, certificate, certification or any other document that is given or used for the aims of present law.

The person in charge that prepares the building efficiency calculations publishes certificates of building energy efficiency, maintains or inspects boiler, installs heating or cooling systems, publishes any false elements with the aim to induce or cause manipulation as for the energy efficiency of the building or is caused, unjustifiably, loss of energy , he/she commits a crime and, in his case of condemnation, it beings in imprisonment for period that does not exceed the two years or in money sentence that does not exceed the ten thousands pounds or even in this two sentences.

Case study 1: Lakatamia, Nicosia

The residence is situated on the south-western suburb of Nicosia, in Lakatamia. Nicosia constitutes the capital of the island and is found in its centre. Due to this, the dry climate with high temperatures and western and north western winds during the summer months play an important role with regards to design. The owner of the house is the architect himself and therefore had the opportunity to apply more determined methods of bioclimatic solutions. The principal element of this research was the design, construction and monitored inhabitation of an Experimental Solar House (ESH) at Lefkosia, taking into account the potential of the well established principles of Passive Solar Design when applied to the specific cultural, economic and climatic contexts of Cyprus.

Different functions of the house are laid out in a square shape. During its course, the architect creates an extension on the length of the southern part of the building as an additional space of daily usage and research. Inside the residence the daily spaces (living room – dinning room and kitchen) are arranged around a central free standing staircase in a bended shape, where it on the ground floor. The second floor is handled in a similar fashion with the bedrooms being assembled around the staircase which is extended with a half circled mass above the roof. Semi-open areas are created on the southern side of the residence through a pergola placed on its face (Figure III.v). Outside, an open yard is created with vegetation and water features that surround the mass of the building. Surrounding the mass of the building, an open yard is created with vegetation and water features.

Figure III.v - Exterior of the house (south facing)

Upon constructing the Experimental Solar House, it was decided that the house should follow the most suitable combination of design parameters of a contemporary Cypriot home. These are:

- Wall construction type: 100x250x300mm brick and 70mm of expanded polystyrene on the exterior, with three layers of plaster on the interior and Adesilex FIS 13 on the exterior sides (U-value 0.296 W/m²k), since it effectively insulates the whole structure and avoids thermal bridges where the columns and beams occur.
- Roof Type: 150mm concrete, 600mm air gap, 3mm water insulation and 100mm of expanded polystyrene on the exterior, with three layers of plaster on the interior and 50mm on the exterior (U-value 0.28 W/m²k - Type 3), since it retains heat (thermal mass) and takes advantage of the reverse beam structure of the roof.
- External vertical louvers: Not used, as they are not 100% suitable, due to the high construction cost and permanent view obstruction of the east and west façade of the house.
- Permanent shading devices: The second floor bedroom windows on the southeast and south walls were recessed to prevent summer sun from entering, but allowing winter warmth to enter.
- Extreme overheated periods: Roof fans are used to assure no overheating would occur.
- Basic principles of passive solar design were used, this include natural ventilation, solar shading devices, mass walls, thermal insulation, sun path diagram (Figure III.vi and III.vii).

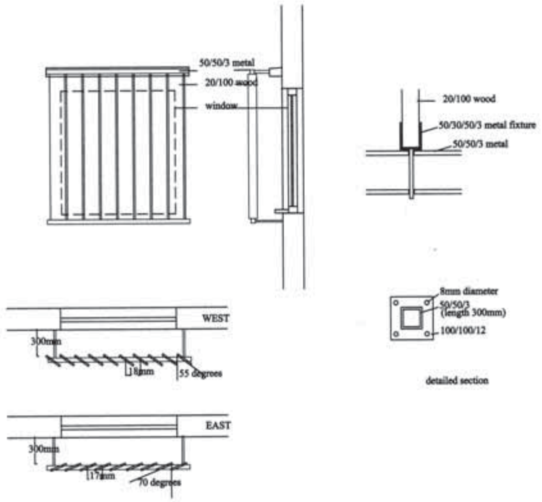


Figure III.vi - Special designed horizontal shading devices for east and west

Through monitoring the ESH the results show that all heating requirements are satisfied by solar energy, while natural ventilation or ceiling fans meet all the cooling needs, concluding that Passive Solar Design may be successfully applied in the design of modern buildings in Cyprus (Figure III.viii). The red line shows the internal temperatures throughout the year. Once this line drops below 19.5°C heating is needed (shown in light red), and once the line rises above 29°C cooling is needed (shown in light blue).

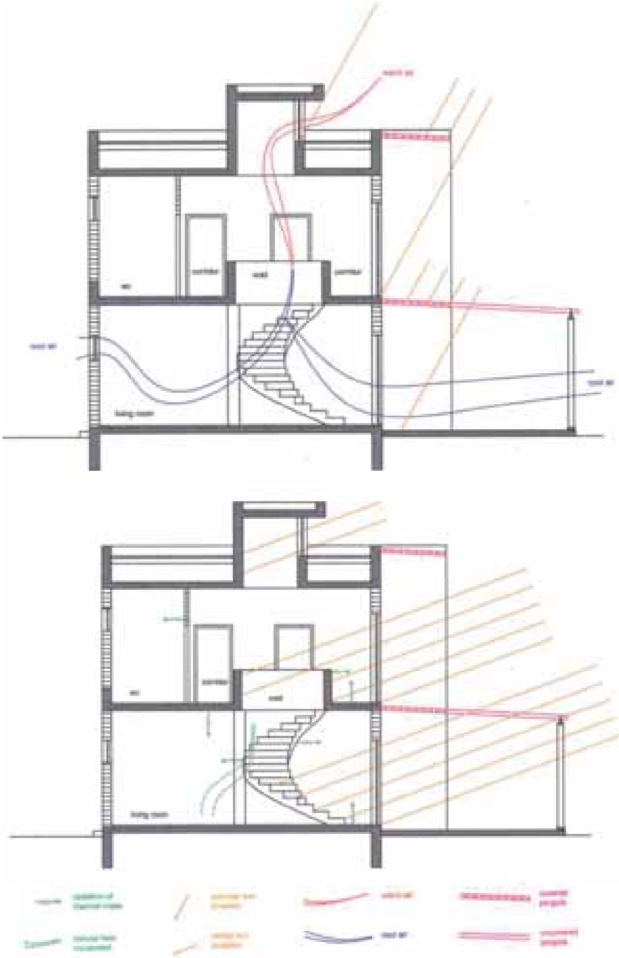


Figure III.vii - Summer and Winter and design considerations (north-south section through staircase)

The external temperatures are shown in a lighter black shade. There are moments during the heating and cooling seasons where the fireplace and fans are not needed, as temperatures rise and drop accordingly.

- The maximum temperature difference between indoor and outdoor temperatures, in the inhabitant period was 10-15°C.
- The internal temperature and relative humidity throughout the year remained steady (within the thermal comfort limits), despite the instability of external temperatures and humidity percentages.
- Fans needed to be used from the 5th July till the 20th August (maximum internal temperature was 31ºC).
- Heating needed for 30 days between December and February (minimum internal temperature 17ºC). The only source of heating was the fireplace that proved satisfactory.
- Daytime ventilation (opening of windows and doors) during the summer caused indoor temperatures to rise unsatisfactorily (up to 36ºC, depending from the external temperatures)
- Once the pergola and the Venetian blinds were installed, temperatures remained at a steady and comfortable level (importance of shading devices)
- The house functioned properly with only a few minutes attention every day, in order to build fires, and operate windows
- Internal relative humidity daily swings were noted at 2-20% (within the comfort zone)
- The Experimental Solar House averages an average energy cost of €50 per month (much lower than that of a contemporary Cypriot house)
- Once the photovoltaic system was installed, this figure reduced to €25 per month.
- The domestic hot water needs were covered 100% by the solar hot water collectors.
- In order to cover cooling potential 100% the pergola and vegetation are necessary
- A tent, vegetation or a permanent overhang is more suitable than the pergola, since they would allow shade in the summer, and solar radiation in the winter
- Once thermal mass effects, exposed mass and night purge ventilation, passive solar heating and natural ventilation, comfort percentages rise exceedingly higher than that of a contemporary home.
- The average total projected energy consumption of the experimental building developed in the research is 44 kWh/m^2a. This is only about 25% of the typical consumption in residential buildings in Cyprus.

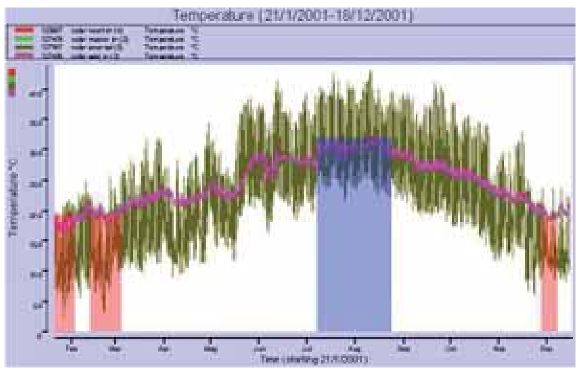


Figure III.viii - Internal and external monitored temperatures for the year 2001

- The average total projected energy consumption of the experimental building developed in the research is 44 kWh/m^2a. This is only about 25% of the

typical consumption in residential buildings in Cyprus.

Case study 2: Oroklini, Larnaca

The Oroklini village of the Larnaca district is situated northwest of the town. The residence belongs to a four-member family. The building structure on the ground is based on a rectangular shape. It is interesting to see the alternative levels on each floor (Figure III.ix and III.xi).

Figure III.ix - exterior south elevation

The residence is laid out on three levels, in which the daily spaces (sitting room, living room and kitchen) are situated on the ground floor, private spaces (bedrooms, offices) are found on the first floor. The area of the staircase stands out externally due to the super-elevation of its floor, something which the architect intended in order to place clerestory windows. The ground floor is divided into two individual departments, one of them being accommodated with the entrance and the living room and the other with the sitting room and kitchen in a united space. The staircase is situated in the north section of the mass, at a central point, in order to suit all its functions. On the first floor the bedroom spaces are placed surrounding the staircase area and the attic directly communicates with these areas through an internal staircase. Semi-open areas are created on the southern and northern sections of the face via overhangs. The northern semi-open space functions as a parking space, while the southern one is used as a yard. The open area is mainly covered with grass and the remaining areas are covered with tiling. There is anticipation to plant trees around the building shell, which hasn't developed to a satisfactory level as yet.

The shading of openings is succeeded with the use of overhangs with the extension of the floors on the southern and northern sections. With regards to east and west, the openings are within the building shell forming an overhang. Inside moveable blinds where installed to control the solar radiation within the house. At the point of super-elevation of the floor of the staircase, clerestory windows have been placed and are opened during the summer months for the warm air to be taken away. Based on the provisions in the daily used areas, there are north and southern openings which, when opened, contribute to the thorough airing of spaces (Figure III.x and III.xi). For the protection of the building shell from thermal losses, insulation materials have been placed in the layers of the floors, in the external walls, as well as the usage of double glazed windows in openings. The building frame constitutes of armed concrete and the building envelope is invested with stone tiles. Tiles are used to protect the floors during the summer months.

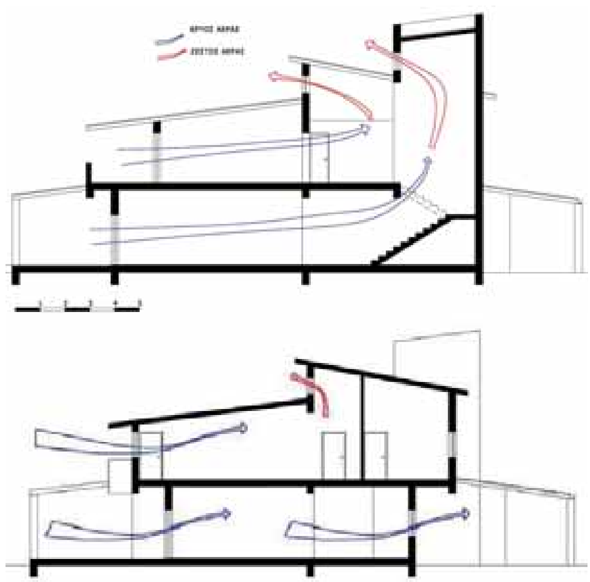


Figure III.x - South-north cross sections showing the natural ventilation

According to the residents, the conditions inside the house during the summer months are ideal. This is mainly due to the insulation in all the building shell avoiding thermal bridges, but also due to the secured airing systems created by the architect. At the point of elevation of the staircase, there are clerestory windows which abduct the warm air.

Figure III.xi - Internal view of the southern clerestory windows and internal balcony

Planning legislation

For Cyprus the methodology that was prepared concerns:

- Buildings that are used as residences,
- Buildings that are not used as residences of smaller area (1000 m^2) which do not have central system of air treatment,
- The methodology is in place to calculate the energy needs of a building in Heating, Refrigeration and Production of Hot Water for Use,
- Comparison of individual energy needs of real building with the building of report,
- Includes parameters as efficiency of instruments, contribution RES etc,
- The final result will lead to the certification of building.

The categories of buildings that are excluded from the obligation of observation of minimal requirements of energy output and for publication of certificate of energy attribution of building are the following:

- Buildings and memorials that are officially protected because of particular architectural or historical value, provided that they comply with the requirements of present law would change, at the crisis of the town planning authorities, essentially the character or their look.
- Buildings that are used exclusively as spaces of religious adoration.
- Temporary buildings with a duration of use of maximum two years.
- The section of an industrial installation where the production is carried out.
- Rural or non living from persons buildings, which have low energy requirements and rural non living from persons buildings that are used in a section that has a special agreement for energy efficiency
- isolated buildings with a total useful area of under 50 square meters

The present regulations are implemented in all the cases of construction of new buildings as well as in the cases of buildings of total useful surface above 1000 m^2 that suffer radical renovation. It is comprehended that in the cases of buildings of total useful surface above 1000 m^2 that suffer radical renovation, their energy output upgraded so that it fills the requirements of minimal energy attribution of building, in the level that at the judgement of the appropriate authorities, this is technical, functional and economical feasible.

Urban case study

No specific legislation was ever passed before 80's concerning incentives for organised housing complexes. The only regulatory tools were the commonly used town planning restriction which concern plot ratio, plot coverage, maximum height, maximum number of stories, a general aesthetic framework and some indirect density standards, concerning the minimum surface in relation to the size of housing units. This is actually the very reason that multi-story family buildings were very few till 80's. Some sort of incentives for organized housing complexes up to three stories, were introduced in the revised statutory local plans in 2003.

There are no specific regulations concerning architectural and functional aspects. The authority that is responsible for issuing the Planning Permit, decides whether a certain development rests within the environment of the surrounding area. There are however indirect density standards, concerning the minimum size of housing units.

City case study

The huge housing problem created after 1974 was immediately dealt with by government's initiative and action, beginning with the reconstruction of destroyed areas to alleviate the housing shortage in the cities. As a result, the housing problem passed into the hands of private businessmen. In fact, because of the absence of other investments, the building industry began to play a determining role in shaping the Cypriot economy. The new government took measures towards regulating of the urban space with the purpose of stabilizing the regime. Many image-driven public building projects began and several laws were passed making construction policies less strict. Consequently although the first substantial reductions of some plot ratios (above 200%) were enforced in the main towns, many new development zones were created in order to set the ground for new structures. As a result, private building construction especially focused on tourism and housing industry boomed during this period. A series of reforms was introduced to the new constitution that specifies that the protection of the physical and cultural environment is an obligation of the state. All the reforms reflect the necessity for an adequate planning mechanism in the field of housing and environmental and land use planning. However, the Cyprus government has not yet established many implementation procedures and reserves for itself (4 out of 33 Municipalities) the right to act on any problem by highly centralizing the decision-making process on all these fields.

Contemporary life and the building industry in Cyprus are greatly affected by the proliferation of apartment blocks in the large urban centres. The apartment house became the symbol of the final stage of urbanization. And since urbanization is for certain reason a preferable way of living for the contemporary Cypriot, the apartment model is extensively adopted even in medium size settlements in the countryside.

Cyprus employs a lot of housing systems. Within the context of the housing policy for the refugees, the government of Cyprus has introduced various schemes and programs like the “Low Cost Government Housing Scheme” that provides houses, free of charge, to low-income families. Until 2001, more than 12,500 families (or 5.6% of the total number of households) were benefited from this scheme in 71 housing estates. In addition to that the government provides the “Self-help Housing Program on Government Land” (where 9,000 families, or 4.1% of the total number of households, have already been housed in 321 estates of this type), the “Self-help Housing Program on Private Land” and the “Purchase of a House/Apartment Scheme”. In the private sector, development and construction companies offer in the free market various types of housing units and mainly apartment or terrace houses. This type of development satisfies nearly 30% of the total demand. A substantial number of families however, choose to build their own detached or semi-detached house on an individual plot of land, which has an average surface of 520 m^2. It is worth mentioning that in 2001, 68.2% of the total number of households in Cyprus had their own private housing units. Three categories of construction financing have been developed.

In the first, a contractor undertakes the construction of the building. In the second, the owner of the property decides to play the role of the contractor-entrepreneur and undertakes the responsibility of constructing and financing the project. He usually sells or rents most of the apartments keeping one or two for him. In the third (the gradual method of construction), the owner of the property builds one housing unit for the present needs of his family, allowing for the possibility of constructing additional apartments in the future to cover the needs of the growing family or merely for investment reasons.

The result of this practice in the form of the city is the following:

- Housing areas close to industrial or other areas, dangerous for public health,
- Very limited green and open spaces within the housing areas,
- Bad relation between street width and building height,
- Different housing types even in the same street-large apartment blocks adjacent to low houses,
- Unplanned and often unhealthy interaction between the built and natural environment.

In an analysis of the built environment of the city area, it was concluded that the negative points of the housing environment are not due to the lack of adequate housing units, but to the high cost of the housing units, the lack of big organised complexes, the domination of individual developments in small building plots and the uneven drops of adjacent plot ratios (building area to site area). This results in the lack of open spaces and to the quality of the immediate environment around the houses with restricted ventilation, solar access etc.

National conclusions

Cyprus has ratified different agreements such as the Kyoto Protocol in 1999, United Nations Framework convention on climate change (UNFCCC) in 1997 and the Vienna Convention in 1992. The Memorandum of Understanding on the implementation of the EEA Financial Mechanism 2004-2009 between the Republic of Iceland, the Principality of Liechtenstein the Kingdom of Norway and the Republic of Cyprus was signed on 16th September 2005. The Memorandum of Understanding on the implementation of the Norwegian Financial Mechanism 2004-2009 between the Kingdom of Norway and the Republic of Cyprus was signed on 19th May 2005. Under both Financial Mechanisms projects in the following priority sectors and specific fields of intervention for Cyprus will be supported such as: Integrated pollution prevention and control, Reduction of CO_2 emissions and Management of selective solid waste and possible recycling, i.e. of electric and electronic equipment waste. Promote sustainable natural resources management and efficient use, Sustainable forest management and Implementation of management plans for Natura 2000 sites.

Cyprus government has set amongst the main objectives of the Cyprus Energy Policy the development of Renewable Energy Sources (RES), energy conservation and harmonization of the energy sector with the Aquis-Communataire. The national action plan for RES and energy efficiency calls for doubling of RES contribution to the country's energy balance from 4.5% to 9% by 2010 and increasing the contribution of RES in Electricity production to 6% by 2010. Within the framework of the national action plan for RES and energy efficiency, the support scheme for energy conservation and the promotion of renewable energy sources has been operational since 2004 and modified versions of it will be in force until 2010. The Ministry of Commerce, Industry and Tourism has examined several amendments of the existing support scheme in order to be more functional and effective. The most important amendments are:

- Increase of the maximum eligible installed capacity per unit of photovoltaic that are financed from 5 kW to 20 kW and the maximum amount of grant from €16,200 to €65,000 per unit.
- Increase of the maximum amount of grant provided for the installation of small wind systems with capacity up to 30 kW from €30,800 to €51,300 per unit.
- Grant of €1,200 for purchasing a hybrid or fuel flexible vehicle and grant of €700 for purchasing an electric or a low CO_2 emission vehicle.
- Grant for energy saving investments in thermal insulation, estimated up to €21 million in the next two years.
- Energy saving campaign using compact fluorescent lamps worth €4.3 million until 2010, which are given free of charge to electricity consumers.

It must be acknowledged that all the information and research concerning the municipality laws, the planning laws and the EPBD implementation and generally everything were done in 2008. This might change in the near future, with uncertainty of exactly when and what.

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IV Denmark

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National context

Supply of energy is vital in order to make modern societies function. The total Danish annual consumption is more than 9.3 billion € in total on energy (excluding transport) (Danish Ministry of Transport and Energy 2005). There is a need for ambitious and dynamic energy-conservation efforts. Besides resolving global environmental problems, savings in energy consumption through more efficient energy use also contribute to economic growth and industrial development and to the maintenance of a high level of energy supply-security. According to the Danish Ministry of Transport and Energy (2005) ambitious energy-conservation efforts in order to reduce CO_2-emissions are therefore a central element in an energy strategy that takes long-term challenges seriously.

Denmark is generally renowned for its high environmental profile. It was one of the first countries to address the issue of heat loss from buildings in the 1950s. Several demonstration projects have since been carried out and Building Regulations with regards to heating has been implemented. These early efforts were not only due to sustainability concerns, but also due to lack of and security of energy supply following the war and the oil crisis. These early initiatives were followed by consistent legislation and building regulations and have led to a notable stabilization over 25 years for the energy consumption for the heating of buildings, despite a simultaneous increase in floor area as well as in BNP. Within the last decade the Danish achievements have been less significant. The recent consciousnesses of dramatic climate changes have once again increased political efforts in the area.

Climate

Denmark has a temperate, coastal climate with an average temperature of 16^{o}C in the warmest month and 0^{o}C in the coldest month, and 7.7 ^{o}C in yearly average. The relative humidity is in average 70%, and the precipitation amounts to approximately 600 mm a year.

The Danish climate has a lot of thaw/freeze situations, which together with relative high humidity has a destructive effect on building materials. Local available materials and the climate have therefore favoured a building tradition using heavy materials, primarily bricks, for the building construction. To apply with current building regulations this tradition is slowly changing from heavy and solid to lightweight external wall construction.

Demographics

Denmark has a total acreage of 43.094 square kilometres with a stretch of coast of 7.000 kilometres. The country consists of the peninsula ‘Jutland’ and a great number of islands, of which Zealand represents the greatest. The total population of Denmark is about 5.5 million. Denmark is strategically situated between the North Sea at West and the Baltic Sea at East. The country is inhabited, in average, by 120 inhabitants per square kilometre.

Carbon dioxide emissions

The current release of CO_2 per capita is 9.7 tonnes or 74 million tonnes in total (DEA 2007a; Bach et al. 2006). Denmark currently has a CO_2 emission intensity, which is below the OECD-Europe average, and which has been strongly decoupled from economic growth.

The most important sources for CO_2 emissions in Denmark are: Energy Sector (5%), Transformation in Electricity and District heating production (43%) and Final Consumption in Transport (31%), Agriculture (14%), Trade and Service (2%) and Households (6%). (DEA 2007b). Important reductions in green house gas emissions have been achieved in agriculture, households and waste sector, but much remain to be done with regards to energy, transport and industrial sectors (OECD 2008). The Danish Climate Strategy is mainly based on the Kyoto commitments with the target to reach an emission of 55-60 million tonnes of CO_2 in 2012, which represents a CO_2 reduction of 21% before 2012.

On 10 June 2005, a majority of politic parties in the parliament have adopted a declaration for future energy saving initiatives (exclusive transport) with the aim of saving 7.5 GJ on an annual average during the period 2006-2013 (DEA 2005). Denmark also targets to be among the most effective OECD-countries in pollution reductions, according to the Danish government.

Energy in the DK

Denmark has strategically aimed at improving its energy system. The peat and extracted crude oil and natural gas from the North Sea have been supplemented with other energy sources, like wind power, through strategic investments in development of renewable energy. In Denmark, utilisation of wind power based systems is especially far with both land-based windmills and seashore windmill parks. Also, the electricity and heating systems have been optimized, based on large and small scale combined heat and power plants, and collective solutions for heating, like district heating, have been promoted.

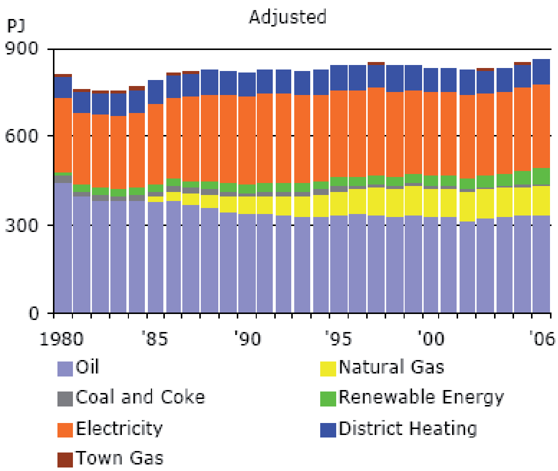

Figure IV.i - Gross Energy Consumption by Energy Product (DEA 2007b)

Having experienced an oil crisis in 1973, the Danish government began to implement long-term energy policy initiatives early on. Some of the first initiatives were mainly substantiated by circumstances of security of supply, whereas more recently circumstances of global climate change and growth and economic development have been emphasised (Environmental Protection Agency 2005a). Denmark also introduced a requirement regarding heat loss for buildings in the Building Regulations already in the 1980s. Promoting energy savings in end-use also has high priority in Denmark. Much emphasis has been put on promoting public awareness about the environmental challenges and communicating ways to promote more sustainable behavior among public authorities, industries and households.

CO2 emission policy measures

Measures to address CO_2 emissions rely on a wide range of diverse administrative and economic instruments in Denmark at different policy levels. These measures are built upon a solid environmental legislation, which has been largely harmonised with and derived from EU environmental directives (OECD 2008). The polluter pays principle has been largely implemented in Denmark, especially with regards to regulation of emissions of households. The Danish regulation policy measures are divided into cross-sector and sector-specific (energy, transport, industry and households) initiatives.

At *state level* several Government thematic action plans set the frames for regulation and policy measures, e.g. ‘Energy 2000’, ‘Energy 21’ and ‘Energy Strategy 2025’. Denmark has a strong taxation policy, implementing a number of different taxes to impact emission of greenhouse gases, including energy taxes and taxes on mineral oil, gas, coal and electricity, and CO_2-taxes. A green tax package was adopted in 1995 in order to encourage Danish industries to reduce emissions. Also, tax differentiation has been implemented especially in relation to registration taxes and yearly taxes to promote energy efficient cars. Since 2001, the Government policy has been to assure emission reductions through improved use of market mechanisms and more cost-effective initiatives (DEA 2005). Besides taxes, the main cross-sector initiatives to assure this are quota regulation and Kyoto mechanisms.

Formerly, *the Regions* in Denmark played a significant role in environmental planning, since they were responsible for inspecting and approving major utility facilities, and for coordinating transportation initiatives. Due to a reformation in 2007 of the Planning Act, the Regions’ roles in this respect have been assigned to either municipalities or the state. This has lead to a split-up of key knowledge centres and insecurity about the future handling of these issues.

At *municipal level*, the national strategies and initiatives are implemented on the basis of local action plans. Municipalities work in close relationship with industry and households, and are responsible for inspection of major energy and environmental facilities. Substantial efforts have been made to promote energy savings in industry, households and the public sector. The main policy tools applied by the municipalities are dialogue, campaigns and inspection. This includes initiatives that make visible the environmental impacts, e.g. through green accounts or similar tools to account for energy consumption. Several Danish municipalities have taken a lead in establishing political agendas for sustainable development. Initiatives include ambitious Local Agenda 21 work and development of inter-communal networks committing to strengthen their environmental efforts (e.g. 'Dogma 2000', the 'Aalborg Charter' and 'Climate Municipalities').

In Denmark, *energy companies* have been instructed to carry out 1% energy savings per year through initiatives towards energy consumers. Also, *energy advisers* have the task of ensuring credibility and control of the energy labelling of buildings, and have a crucial role as advisors for the industry and households.

Denmark has a strong tradition for bottom-up initiatives at the *local level*. Different interest organizations (e.g. the Danish Cyclist Association and the Danish Society for Nature Conservation) are engaged in activities to promote energy savings, either by direct initiatives or lobbying for improved regulation. Other local actors like social housing agencies and eco-groups carry out supportive activities. In that sense, many initiatives in Denmark are actually taken at the local level.

Building Regulations

The Danish building legislation is mainly based upon the Building Regulations, which describe building requirements. The regulations are developed by the Danish Enterprise and Construction Authority, which is part of the Ministry of Economic and Business Affairs. The regulations are implemented through the municipalities, which develop local plans and approve local building projects.

The enactment and enforcing of building legislation mainly occur through the Planning Acts, where Local Plans regulate the appearance and use of buildings in a specific local area. In order to construct or renovate a building, the municipality must approve a building project application. During this application process, the municipal caseworker checks that the project lives up to all existing legislation, including the Planning Act, Building Regulations and Local Plan.

EPBD implementation

Denmark has widely adopted EU building directives in its Building Regulations. The regulations have been recently reformed accordingly, especially in terms of energy requirements for buildings.

Calculation method

The energy performance of new buildings is mainly regulated through a minimum requirement, where the energy performance of the building is calculated. This methodology for setting up requirements was already introduced in 1997 in Denmark by the Danish Building Research Institute, and since in the European Energy Performance of Buildings Directive.
In order to get approval of a building project, the building has to document compliance with the minimum energy performance set in the Building Regulations. Guidelines number 213 on the Building Regulations prescribes the use of the calculation programme 'BE06' for this purpose. This guideline contains the tools for calculating the energy performance of the building and a user's guide. The instruction does not prescribe use of specific technologies, but the Danish Energy Agency prescribes that electricity counts as a factor 2.5 in the calculation. This factor corresponds roughly to the amount of surplus of CO_2 emissions from electricity production pollutes compared to other forms of supply.

Current experiences in building low-energy houses show that a shortcoming in this calculation methodology is that it is difficult to document the energy efficiency of certain technologies, since data simply does not exist from the manufacturers.

Energy performance requirements

The level of energy performance requirement is determined by the following equations, adjusted to different types of buildings:

For residential buildings, dormitories, hotels and the like the equation is: (70 + 2200/A) kWh/m^2 per year, where A is the heated floor area.
For offices, schools and institutions the equation is: (95 + 2200/A) kWh/m^2 per year.

A progressive transition of the energy requirements in the Building Regulations is currently planned with 25% reduction in 2010 and additional 25% in 2015 and 2020. An important change in the reformed Building

Regulations has been to introduce two optional low-energy classes, expressed by the following equations for residential buildings:

Low-energy class 2 corresponds to (50 + 1600/A) kWh/m2 per year
Low-energy class 1 corresponds to (35 + 1100/A) kWh/m2 per year.

The minimum energy performance requirement mainly applies for new buildings, but existing buildings may also be included in cases of major renovations. In existing buildings, implementation of energy saving initiatives is limited to measures that have sufficient profitability. For example, this means that measures mentioned in an eventual energy certification should be carried out in cases of major renovations.
Certain buildings are exempt from this requirement, including churches, museums, listed buildings and other buildings worth preservation.

Energy performance certificates

The energy performance of existing buildings is mainly regulated through a certification system, which is mandatory for residential, industrial, commercial and public buildings. For existing residential buildings, a certificate has to be worked out, when a building with an area of more than $60m^2$ is sold. The seller of the dwelling has the duty to work out a certificate, and this is often arranged in cooperation with the real estate agent. The certificate is valid for five years. For new buildings, a certificate has to be worked out before the building is taken into use. The developer of the building has the duty to get the certificate worked out. For public, industrial and commercial buildings the same guidelines apply, although certain buildings for industrial and agricultural use are exempt from the requirements.

The energy performance certificate contains an overview of the total energy consumption of the building and the possibilities of reducing consumption of heat, electricity and water. The total energy consumption includes energy consumption for heating the building and for operating built-in building installations. Each building is given a rating from A to G, where A is best. Certain proposals for energy saving measures are stated in the certificate, including an estimation of the costs and savings.

Administration of the energy performance certificates is carried out by a specific secretariat dealing with inspections and certification schemes. The energy performance certificates are worked out by appointed energy consultants. These consultants are approved by the Danish Energy Agency, who is also responsible for checking the quality of the work. An energy consultant must have an educational background as engineer or chief engineer, building technician or the like, and two years of documented professional experience in consultancy regarding building technology and energy. An energy consultant must pass a five days course in order to be approved by the Danish Energy Agency. Specific guidelines have been established for how energy consultants should go through the building and evaluate the conditions and installations of the building in relation to energy.

Other initiatives

The Danish state has implemented other measures than the above in order to improve the energy performance of Danish buildings.

An important measure has been to abolish the former connection duty for district heating. This duty is strongly coupled to the paradigm of security to supply and represents a barrier to optimize the building construction or implement alternative energy systems (e.g. solar heating, geothermal heating, etc.), since it favors existing supply systems. By abolishing this duty, greater economic incentives have been provided to invest in low-energy buildings, since the relatively costly district heating may be substituted for cheaper heating solutions (e.g. efficient heat pumps).

Another important measure relates to information campaigns and education of citizens and businesses in energy savings. Also, more general schemes regarding sustainable building design and operation have been developed. An example of this is an ICT-based tool ‘BEAT 2002’ aimed at helping to facilitate environmental project design in the building industry.

Previously, Denmark was renowned for its many demonstration projects, experimental buildings in urban renewal and grassroots-based experimental buildings (Jensen and Gram-Hanssen 2007). These experiments were based on national research funds and subsidies, which the current government has removed. This is due to a strategic stand point that sustainable solutions must be promoted on mainstream market terms, and should not be sustained by public subsidies. Some national funding is still available for demonstration or research projects involving innovation and energy savings. Also, several projects in Denmark have gained granting from European subsidies.

Case study 1: New Rockwool Research Centre

One of the first initiatives to build a low-energy office building in Denmark came from a private company. Rockwool International A/S produces mineral wool, and have about 8,500 employees world wide – 700 in Denmark alone. The company was originally founded in Denmark in 1909, and the Rockwool Group headquarters are based in Hedehusene, near Copenhagen.

Figure IV.ii - The Rockwool Research Centre, view from northwest. Architect: Vandkunsten

In 1999 the company decided to build their new research centre as a low-energy office building connected to the existing headquarters. To apply to the Building Regulations at the time (BR95), the building had to perform a maximum of 196.7 MJ/m^2 per year i.e. 54.6 kWh/m^2 per year for heating and ventilation. The aim was to reduce the energy consumption to 15 kWh/m² per year.

In addition the client wanted to focus on achieving a good indoor climate especially concerning thermal comfort, lighting and air quality. At the same time, it was considered important to obtain a building of high architectural quality serving as a high profile marketing of their products. Both architecturally and technically the aims were high, and the company was focused on the unique possibility of using the building project as a learning process. Some of the used Rockwool products were developed during the construction period. Early in the process it was decided to focus on a substantial monitoring and evaluation of the energy performance. The results have been published on the company's website from the beginning.

The Building

The new research centre was completed in summer 2000 and has a total floor area of 4,200 m^2. It comprises test rooms and open office areas and consists of narrow building volumes in order to maximise the amount of daylight in the working areas. The total window area in the building is 35% of the floor area. The building is entered through a hallway facing south, where the building is cut into a slope.

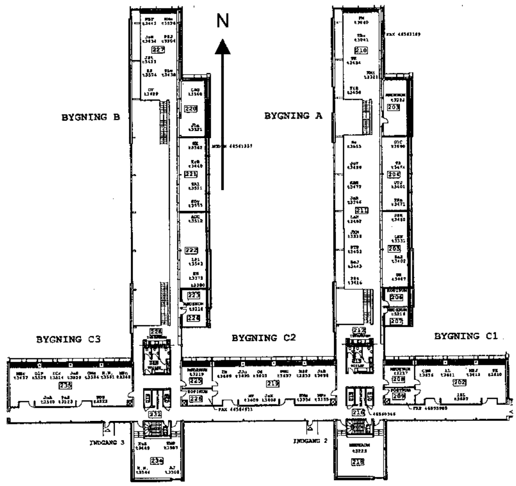

Figure IV.iii - Plan, 2. floor

The following design features were used in order to achieve low energy consumption:

- Airtight, highly insulated building envelopes with 250 mm insulation in the floor, 450-470 mm in the facades and 490 mm in the roof. The east facades are clad with mat black Rockpanel boards. The west facades are clad with a 6 mm rain-screen of tempered glass.
- Special designed Triple-glazed windows with double coated glass. Cavities are filled with krypton gas. The U-value for the glass layers alone is 0.45 W/m^2/^{o}K. The glass and the frames have a total U-value of 0.85 W/m^2/^{o}K.
- Automatic control of lights to ensure low electricity consumption.
- Natural ventilation with automatic control except for mechanical exhaust from bathrooms and kitchens. The air flow rates are low, but carefully chosen, in order to limit heat loss from natural ventilation without compromising the indoor air quality.
- Night cooling of office areas in the summer.

- Solar panels on the roof produce hot water for the bathrooms (33 m^2).
- LCA screenings of load bearing constructions and materials. All materials were accounted for and a Life Cycle Inventory of the whole building was drawn up.

The automatic control was substantial and included controlling the artificial lights, opening and closing the windows, controlling the blinds and turning the heat on and off. However, the system could at any time be overruled by the user.

The load bearing structure consists of steel with Rockwool Conlit fire proof insulation that was partly developed especially for the building. The floors are concrete with wooden flooring in the office areas.
The heating system is a conventional gas boiler with radiators, originally planned to be used only in cold periods in the wintertime as well as for short periods after holidays and weekends, when the building has not received any heat gain from electronic equipment or persons.

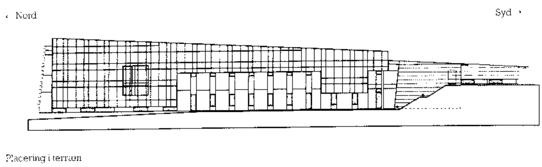

Figure IV.iv - West façade

Cost

The building costs were in year 2000 approximately 1810 € per m^2 not including the price of the site. The price of the special designed windows was approximately three times the price of normal windows.

Performance evaluation

To ensure an impartial evaluation of the energy performance the Technical University of Denmark and the Danish Building Research Institute were asked to be in charge of a substantial monitoring and evaluation programme during the first year. A substantial number of sensors were placed in and outside the building and inside the construction to provide detailed data concerning climate (e.g. solar radiation and outdoor temperature), construction (humidity, heat flux and temperature), indoor environment (temperature, relative humidity and CO^2) and energy (kWh and energy meters). At the same time internal loads from PCs and artificial light was registered as well as the number of people in the building. Finally, a questionnaire survey was carried out to establish the satisfaction with the indoor climate among the end users.

Results showed that the energy consumption for heating and ventilation during the heating season 2001/2002 was 51.4 kWh/m^2 per year and therefore substantially higher than the expected 15 kWh/m^2 per year.

The following problems were identified as the main reasons for the lack in performance (Aggerholm et al, 2003):

- Thermal bridges in connection with the convector pit due to insufficient insulation.
- Thermal bridges in the windows. The total U-value of the glass and frame turned out to be 1 W/m^2/^{o}K in stead of the expected 0.85 W/m^2/^{o}K.
- Unrealistic expectations of the amount of solar gain that could be utilized and the amount of heat gain available from electronic equipment and persons.

Additionally, there were problems with the automatic regulation system that failed regularly. It was also established that the problems above could not account for the total lack in performance. In order to reach the goal of 15 kWh/m^2 per year the lesson learned from this building project showed that (ibid):

- The building orientation must be optimized.
- The size of the glass areas should be carefully assessed
- Detailed calculations should be performed and the heat loss of thermal bridges, e.g. at windows and foundations, should be documented
- It should be taken into account that the comfort temperature in open plan offices is a couple of degrees higher than the usual design indoor temperature of 20º C
- The exploration of the heat gain in open plan offices should be assessed in detail
- During design, focus should centre on heat loss as well as careful control and documentation of the heat loss.

A questionnaire survey showed that the users were fairly content with the lighting and thermal comfort and that noise in the open area offices was the most significant complaint about the indoor climate. However, the substantial automatic control of lighting and ventilation was never fully accepted by the users and caused problems at peak value periods, where the temperature was considered either to low or to high. The system was soon changed, as it was constantly overruled by the users anyway. Instead, the windows now open 5-10 min at specific times in the morning, at lunch time and in the afternoon.

In order to improve the performance, the convector pit was insulated, and together with an improvement of the computer and control systems this resulted in a decrease in the energy consumption for heating and ventilation to 39 kWh/m^2 per year in 2005. In addition, the building has a consumption of 20 kWh /m^2 per year for lighting etc. The consumption has been constant for the last couple of years. In order to apply to the energy demands in the new Building Regulations (BR08), the building has to perform a maximum of 95 kWh/m^2 per year for heating, cooling, electricity (multiplied by 2.5) and hot water consumption. With a consumption of approximately 90 kWh/m^2 per year the building applies to the strict demands of the new Building Regulations (BR08). Consideration was given to modifying the windows in order to eliminate the thermal bridges and further improve the energy performance, but the costs were judged too high.

Perspective

The company has been open about the experiences gained from both the construction and the management of the building, resulting in an extensive pooling of experiences from the project. At the same time the building process has encouraged the company to engage itself in the development of passive house building systems. A possible fear of bad publicity in connection with the openness about the flaws in the performance of the building has turned out to be unfounded. Instead, the impression is that the openness and frankness with which the company has addressed the problems has been met with respect from collaborators and the building industry in general.

The case shows a significant difference between estimated and actual energy consumption. Legislation is not enough in order to achieve a reduction in energy use and carbon emissions, as Building Regulations mostly apply to new buildings. A substantial monitoring and evaluation of the energy performance of buildings in use is necessary as well as a further understanding of the impact of end user behaviour and comfort levels on energy performance needs to be taken into account. Simple, easy understandable control systems have in this case shown more likely to be accepted and successful than more advanced, automatic systems.

Planning legislation

Denmark has a long tradition for employing spatial planning and regulation to assure an environmentally responsible spatial development. In spatial planning, restrictions are made on where to build in order to promote more sustainable settlement patterns. Development of compact cities represents a central ideal in Danish spatial planning.

The Planning Act describes legislation with regard to spatial planning in Denmark. It has recently been reformed and now delegates responsibility for spatial planning to the Minister for the Environment, five regional councils and 98 municipal councils. The Ministry for the Environment has authoring responsibility.

In the Danish system, the central government is responsible for authoring the legislation, whereas the local governments are responsible for interpretation and enforcement. The system is characterized by having a strongly decentralised division of tasks and by highlighting public participation in the planning process (Ministry of the Environment 2007).
After the recent reformation, municipal councils are responsible for comprehensive land-use regulation at the municipal and local levels with legally binding guidelines for property owners. The regional councils prepare a strategic plan for spatial development in each region. The Minister for the Environment is responsible for upholding national interests through national planning and takes care of complex cases related to the environment, nature and spatial planning. The national, regional and municipal plans are updated every four years. Planning cases may be appealed with respect to legal questions to the independent Nature Protection Board of Appeals under the Ministry of the Environment.

Current planning legislation is criticized for not being ambitious enough in terms of promotion of low-energy buildings (Elle and Hoffmann 2006; Teknologirådet 2008). A crucial inexpediency in the current system is that the legislation narrowly delimits what to regulate in the building. Due to the intricate character of regulations, the municipalities lack the abilities to construe the juridical limitation of current legislation. Several municipalities have tried to be front runners by imposing strict energy requirements, but have been instructed by the Ministry that their initiatives might violate the juridical paragraphs. With a recent reformation of both the Planning Act and Building Regulations it has become easier to set up energy requirements in local plans. Specifically, new low-energy classes have been included in the Building Regulations, which municipalities may refer to in local plans.

Urban case study: Albertslund

Albertslund is a suburb of Copenhagen and a separate municipality with 29.000 inhabitants. The community was planned and developed over a very short period from 3.000 inhabitants in 1963 to 31.000 in 1975.

Figure IV.v - Location of Albertslund in Greater Copenhagen

The City Council of Albertslund has since 1995 had a vision of a sustainable town with respect to the environment to ensure that the natural environment is preserved and environmental considerations are integrated in all aspects of the town.

In the UN conference on environment in Rio de Janeiro 1992 the agenda 21 was adopted, emphasizing that local authorities in the different countries should at the latest in 1996 initiate cooperation with the community to obtain agreement on a local Agenda 21 for the municipality.

The following agenda for initiatives in the municipality of Albertslund was presented in 1995:

- The environmental factors in Albertslund should be described in figures
- Green accounts should be further developed
- Urban Ecology Fund – to support initiatives in local communities
- Use of CFC and other climate offending gasses should be stopped immediately
- Environmental policy for municipality purchases
- Policy for heating-, water- and waste-removal tariffs
- Investments (i.e. for accumulating tanks for hot water for district heating)

Although nobody knew what a sustainable town looked like, the vision to develop Albertslund into a sustainable town was created. The vision had to be reflected in all activities of the town: In urban development, in the consumption and use of natural resources, and in the co-operative relationship between the municipality, residents and businesses of the town. Consideration for the natural environment should be a natural part of everyday life at schools and in institutions, in residential areas and in the cultural and social activities of the town. The vision of the sustainable town is based on the re-establishment of natural cycles and respect for ecological sustainability - in other words not to consume more resources than permissible to give succeeding generations the same opportunities, that is enjoyed today.

Dogma 2000

The City Council of Albertslund has taken the initiative for the co-operative relationship Dogma 2000 for municipalities and the environment. The objective is to maintain and develop the work for an environmentally sustainable development in co-operation with other municipalities. Dogma 2000 is a binding partnership that affects all environmental activities in the town. The co-operation comprises the municipalities Albertslund, Ballerup, Fredericia, Herning, Kolding, Copenhagen and Malmoe (Sweden).

The co-operative relationship builds on three principles three dogmas that provide the framework and objectives for the environmental efforts:

- Dogma 1: Mankind's impact on nature must be measured
- Dogma 2: Agenda 21 plans for improving the environment must be prepared
- Dogma 3: Environmental work must be anchored in the local community.

Measuring

The Green Accounts of the City of Albertslund are published in June every year at an event, where the year's green initiative prizes are also awarded. The Green Accounts shows figures for the consumption of heat, electricity and water both at a city level, a district level and at the single family level for the past year and for the previous 3 years to show improvements and the opposite (see *Figure IV.vi*). The initiative prizes can be

awarded to individuals, residents' groups, public institutions and businesses which have made a special effort to disseminate knowledge on environmental matters and to include consideration for the environment in their daily activities.
The small green accounts are distributed door-to-door in the residential areas in September and give rise to dialogue with many residents on the use of energy and water in houses. The small green accounts are targeted at the individual residential areas and thus close to the individual household.

Through *the incentive rate* the consumer is rewarded financially for making the best use of his or her heating. Better utilisation also yields an environmental benefit as it reduces the CO_2 loading from the district heating plant. The better the consumer cools the recirculation water, the better utilisation of district heating. The incentive rate has led to a noteworthy improvement in the use of district heating. The table shows that cooling of recirculation water is heading in the right direction.

	Inadequate cooling ° C	**Additional payment dk.kr.**
1998	3.11	202,000
1999	2.49	155,300
2000	- 0.76	-50,000
2001	- 2.70	-208,000
2002	- 2.30	-183,000

Note: In 2000 the additional payment turned into a bonus for Albertslund Heating Works and led to a reduction of the MWh rate.

Table IV.i – Connection between inadequate cooling of recirculation water and payment, Albertslund 1998-2002

Plans

The municipal plan strategy and municipal plans comprises a green tendering policy for the town of Albertslund's calls for tenders, a CO_2 plan (CO_2 emissions must be reduced considerably within the next 50 years. Albertslund's total energy consumption (in terms of CO_2 emissions) made up of
Transport: 36% - Energy consumption, municipal buildings: 4% - Energy consumption, residences: 22% - Energy consumption, business: 36% - Other public consumption 4%.

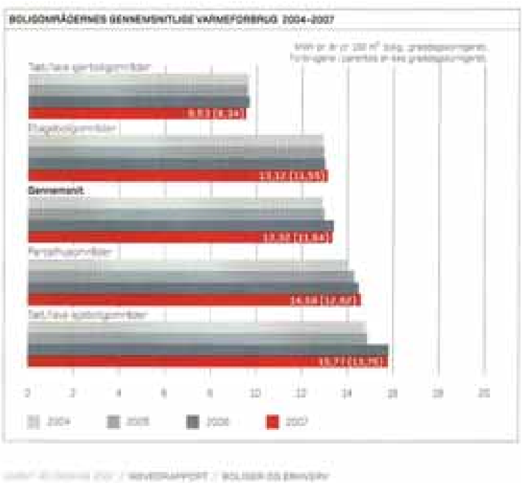

Figure IV.vi - Example of a figure from a green report. Here showing the average heat consumption of dwelling areas from 2004-2007

The composition of energy consumption forms the basis of a CO_2 action plan which covers the following plans: An energy saving plan for energy savings in residences and business - A plan for energy savings in municipal buildings - A traffic plan - A lighting plan.

Regarding the calculation of CO_2 load from traffic, it has been examined whether the calculation of CO_2 load from traffic contained in the Green Accounts could be changed to cover Albertslund as a limited geographical area but so far the calculation must still be based on country average figures as local data is not available.

General objectives for traffic and energy supply: CO_2 emissions must be reduced to ca. 70,000 tons by the year 2050, equivalent to a reduction of ca. 80% relative to 1986. The following interim objectives for CO_2 emissions have been set for the years to 2050:

	Year	Tons	Reduction relative to 1986
CO_2	2010	170,000	50%
	2020	140,000	60%
	2030	100,000	70%
	2050	70,000	80%

Table IV.ii – Interim and long term objectives for CO_2 emissions in Albertsland 2010 – 2050

The energy savings plan was adopted in 2002. If the energy savings plan is implemented, it is estimated that a CO_2 reduction of up to 15.000 tons in residences and business can be achieved. Add to this the planned energy savings initiated by the combined district heating/electricity plant, ENERGI E2 A/S: The commissioning of Avedøre 2 and the wind energy park in Rødsand, which will mean a reduction of CO_2 emissions of approximately 20.000 tons in Albertslund.
If it is assumed that 10% of energy can be saved in municipal buildings, this will be equivalent to savings of approx. 800 tons of CO_2. CO_2 loading from traffic has been steadily rising through many years. Everything thus suggests that Albertslund in best case can expect status quo for CO_2 emissions from traffic.

Anchoring – the User Group

Albertslund has a long and almost unique tradition of residents involving themselves in user councils and boards in municipal administrations and institutions. In environmental issues the 'Albertslund User Group' is helping to strengthen the dialogue between residents, politicians and administration. The members of the User Group are representatives from all residential areas in the municipality. The User Group is the municipality's partner in all areas concerning the supply of services. The User Group expresses its opinion on all matters of environmental significance within areas concerning the supply of services. The User Group and the City Council have established an urban ecology centre - the Albertslund Agenda Centre - with the mission to promote the Agenda 21 work..

Status

	CO_2 emissions Equivalent to a Reduction of …%
Previous consumption Impact in 1986	340.200 t
Status 2002	201.587 t 41%
Status 2007	181.973 t 47%
Interim objective 2015	137.000 t 60%
Long-term objective 2050	70.000 t 80%

Table IV.iii - Status for Albertslund's CO_2 emissions

In 2009, Albertslund Municipality has agreed upon a Climate Plan 2009 – 2015, which in details describes how the interim and long-term objectives are achieved. Albertslund Municipality has received awards, prices and nominations in numbers for its progressive policy on sustainability and intensive involvement of citizens and users, which obviously has led to significant results.

City case study: Greater Copenhagen

Greater Copenhagen represents a strategically important area for CO_2 reductions in Denmark, since one third of the Danish population resides in this area. The area is situated on the north-eastern part of the island of Zealand (average latitude of 55^o north and altitude of 35 meter above sea level). It consists of the inner city and suburbs of Copenhagen and of municipalities in the outskirts of Copenhagen. The total acreage of the area is 2.673 km^2 and the population is 1.8 million inhabitants, providing a population density of 686 inhabitants per km^2.

Spatial planning

Spatial planning in Greater Copenhagen is based on the ideal of the compact city. This means that the overall principle for localisation of urban development is to place urban functions that generate more personal transport in close proximity to railway stations. A crucial element of the implementation of this ideal is the so-called 'Finger plan', developed in 1947 by urban planners Steen Eiler Rasmussen and Peter Bredsdorff. This plan represents a regulation tool, because there is a decree regarding rural zone administration in the Planning Act. These special rules for development in rural zones define whether a specific area can be settled or not in order to avoid sprawling (Ministry of Environment 2007). This finger plan has provided the basis of the spatial development of Greater Copenhagen. In this plan, the ideal of the compact city is embraced, since urban areas are mainly developed in connection to the S-train system formed as a hand. This concentrates working places near the railway system and assures easy access to green areas in the spaces between the fingers.

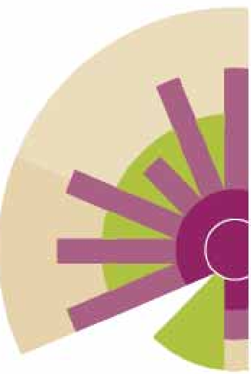

Figure IV.vii - An illustration of the Finger plan. The fingers represent urban areas, whereas the space between the fingers represents green areas. (Ministry of the Environment

The plan determines four geographical sub areas:

- The inner city of the area (the palm of the hand), where no further urban zones will be designated, but where urban renewals will be carried out.
- The outer urban area (city fingers), where urban development may take place.
- The green wedges, not to be designated as urban zones, but maintained as recreational space.
- The remaining capital city area, with emphasis on development on local conditions.

The ideal of the compact city is not always implemented in practice, since other forces push for urban development in rural areas. According to Hartoft-Nielsen (1997) it is difficult for some municipalities to implement the principle of close proximity to stations in Greater Copenhagen. Several examples of scenic localisation of industries have been seen during the last decades.

Transportation

With respect to transportation, Denmark has a well-developed public transport system, and in the bigger cities good conditions for biking have also been furthered. Several major transport infrastructure projects have been launched in order to cope with increases in the transport sector, including the Copenhagen metro and the Copenhagen Circle Line project.

In Greater Copenhagen the finger structure of the urban development has proven good in order to coordinate urban development with the traffic system in order to assure an urban area of high quality and an efficient and sustainable transport pattern (Ministry of the Environment 2007). The area is currently connected by means of an overall net of radial rings of railways and lanes. These radials stretch from the city centre to five major market towns on the outskirts of the area and are serviced by a public railway system, regional trains, metro and motorways. The traffic system was originally primarily oriented towards the central parts of the urban centre, but today much of the traffic flow now moves across the city fingers. This has required an expansion of the ring connections.

The Copenhagen area currently deals with a lot of congestion problems on the main roads of the area as a result of increases in transportations by car. Measures have been taken, including construction of a metro system in the city centre and expansion of main roads. More radical measures, such as a road pricing are discussed, but has so far not gained political majority outside the city hall of Copenhagen. In Denmark, transport by private cars still has high priority, although the car-share is only 378 cars per 1.000 dwellers in Denmark.

In the city centre of Copenhagen there is a high number of cyclists. The modal split in the core centre of Copenhagen is one third divided between pedestrians and cyclists, public transport and cars. Whereas 56 % of families in Denmark have access to a car, the share is only 29 % for Copenhagen and Frederiksberg. These numbers reflect a big share of cyclists in Copenhagen compared to other urban areas in Denmark (and the world). Different strategies have been implemented to strengthen bicycling in the city, e.g. expansion of cycle lanes, development of independent bicycle route systems, etc. Also private initiatives like the 'bike bus' have been established, where a group bicyclists meet up and cycle 35 km from a suburban city to the centre of Copenhagen together, shielding each other from the wind.

Buildings

The area of Greater Copenhagen is characterized by having blocks of flats (generally 4-5 floors) in the centre of Copenhagen, low dense buildings in the suburban city centres and detached houses in the suburbs. The settlement of the area has been made in phases, first developing the inner city before 1910, then expanding the city centre during the 1920s and 1930s. The settlement of the suburbs took place in the 1960s and 1970s. During the 1980s there was a boom in industrial and commercial buildings in the area. Since the end of the 1990s a new building boom has taken place, which is currently in a process of recess. In 2001, approximately 800.000 m^2 of industrial and commercial buildings were constructed in Greater Copenhagen and 3.500 dwellings (Ministry of the Environment 2007).

Different initiatives have been taken in order to keep up the quality of the buildings in Greater Copenhagen. Within the city centre, a number of urban renewal projects have been carried out. Several of these projects financed by public subsidies have integrated sustainability as a dimension. For example, several urban renewal projects in Vesterbro, a quarter in central Copenhagen, implemented experiments from low-energy buildings or attempted to apply grassroots' experiences to an urban context. In the suburbs, existing buildings have continuously been renovated through subsidies from a pool of money for renovation. Also, the Danish Building Defects Fund was established in 1986 as part of a Quality-assurance and Liability Reform. This fund has been an important driver for renovation of buildings from the 1960s, but only within the social housing sector. Especially buildings from the 1960s represent a critical area for energy improvements, since the quality of these buildings is poor. A recent report on renovation of a large area of terraced houses in the suburbs of Copenhagen suggests demolition of the dwellings rather than renovation, due to poor quality (Andersen 2008). From the 1980s and until 2001, several types of subsidies pushed renovation of existing buildings. The current government has had little focus on this aspect, although the need for renovations is great.

National conclusions

Denmark has for decades represented a frontrunner in low carbon built environment, but is currently outpaced by other EU countries. The past development has been characterised by strong individual eco-housing projects and major urban ecology demonstration projects. Also, social housing organisations have been frontrunners in promotion of sustainable new built and renovation of existing dwellings. The general picture, however, is that the Danish building sector is slow to implement the most energy efficient building methods, according to a recent critical report (Teknologirådet 2008). This is although much emphasis has been put on improving the efficiency of heating consumption in buildings in Denmark.

The municipalities currently represent important players to promote low carbon built environment, since they show a great will to implement initiatives. However, the overall framework needs to be improved in order to support the engagement of more municipalities in such initiatives (Teknologirådet 2008). The recent tightening of the Building Regulations and the reform of the Planning Act are important measures, but much can still be improved.

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V EcoCity China

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Introduction

The EcoCity China chapter is based on the results of the research cooperation between VTT Technical Research Centre of Finland and People's Government Mentougou District Beijing, the Mentougou Science and Technology Office and the Tsinghua University. The aim of the study is to find innovative and feasible solutions to sustainable urban development in the Miaofeng Mountain town area based on the latest technologies and innovative solutions in urban development including construction, use and maintenance of built structures, energy production, transportation, water and waste management systems as well as agriculture supporting urban areas and modern urban living. The climatic conditions in Finland and Beijing area are different, which means that the ecological issues must be treated taking into account the local conditions in Beijing district area and especially in the mountain area. The low-energy and low-emission urban development in Chinese climatic and cultural conditions can look different compared to the Finnish equivalent. Despite the fact there are common technologies, principles, rules and methods how to achieve more sustainable development than with business-as-usual approach. The Finnish experience of similar approaches were tested in the study area on a conceptual level.

National context

People's Republic of China is the largest country in the world by population (over 1.3 billion inhabitants) and second largest in land area (9.6 million km^2). The average density is 140 inhabitants per km^2. The densest parts are around Shanghai and Beijing Cities. During the last decade the Chinese cities grew on the average by 10 % annually. The large size means a great variety in climate and other geographical conditions as well as in building tradition and other parts of human culture.

The Miaofeng Mountain town is located about 30 km west of Beijing and 5 km north of Mentougou City. Miaofeng Mountain town consists of 17 villages. The Miaofeng Mountain town EcoCity project is a first of a kind environmental project between the People's Republic of China and the Republic of Finland. The concept development produced a vision of an EcoCity to be built in Miaofeng Mountain town area, along with a concrete plan including short-term actions for the near future. The results will be used as reference models for similar types of development in other parts of China.

In the Miaofeng Mountain town, ecosystem and landscape degradation is one of the negative consequences of opencast stone mining. Investment on financial, human and social capital in the restoration of damaged ecosystem is essential to assure ecological sustainability. The Miaofeng Mountain town EcoCity project is promoting a self-sustainable semi-natural system mainly in the deserted quarries and preserving the relatively undamaged ecosystems.

The new construction will be located both on brownfield areas and existing villages. The deteriorated landscape will be restored to semi-natural and cultural area. In general, there are two primary characteristics of the development: restoration of ecological processes and making restoration affordable and sustainable.

Climate and geography

The climate in and around Beijing area is a monsoon-influenced humid continental climate. The summers are hot and humid due to the East Asian monsoon. The winters are generally cold, windy and dry reflecting the influence of the vast Siberian anticyclone. Average daytime high temperatures in January are at around 1°C, while average temperatures in July are around 30°C. In 2005, the total precipitation was 410 mm; the majority of it occurred in the summer (Wikipedia).

The Miaofeng Mountain town area is located in the closest mountain area west of the Beijing city. Dust from erosion of deserts in northern and north-western China results in seasonal dust storms that plague the city. In the first four months of 2006 there were eight such storms. In April 2002, one dust storm dumped nearly 50,000 tons of dust onto the city before moving on to Japan and Korea (Wikipedia).

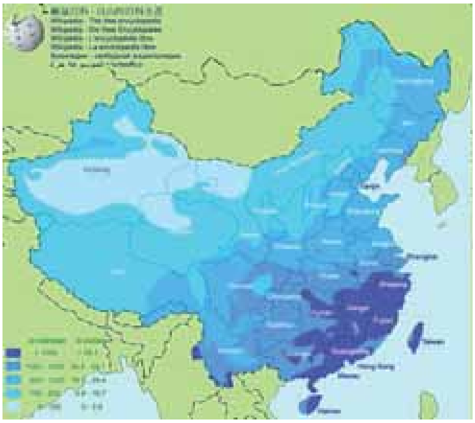


Figure V.i - Annual rainfall in China (Figure: Wikipedia)

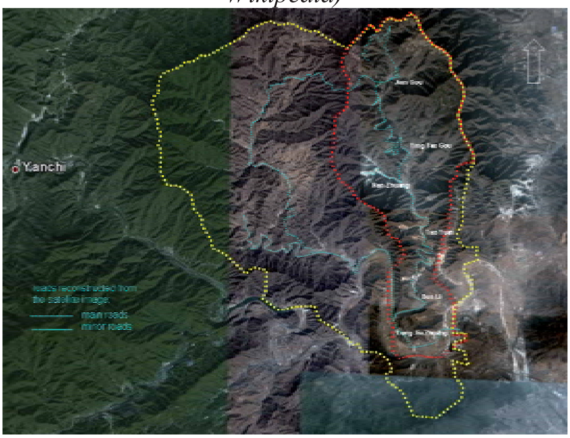


Figure V.ii - Miaofeng Mountain town. The present structure utilizes Eastern and Western north-south oriented valleys. The priority development villages (white names) locate in the Eastern valley. Satellite images by GoogleEarth

Major part of the Miaofeng Mountain town area is mountainous limestone area with high variation of altitudes (Figure V.iii).

The areas southern part is served by a river fed by smaller creeks from north. The proposed EcoCity area covers the whole Miaofeng Mountain town (Figure V.ii). Six of the villages have a status of priority development village.

Demographics

The present registered population of Miaofeng Mountain town is 7,189 inhabitants. The largest village had 1,084 inhabitants while the smallest even less than 100 in 2007.

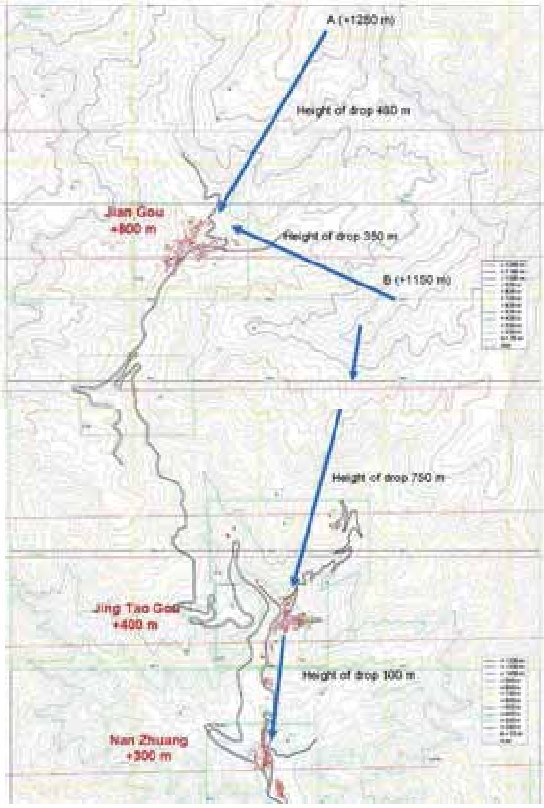


Figure V.iii - The topography of the Miaofeng Mountain town eastern part characterized by high altitude differences

The size of the Miaofeng Mountain town EcoCity is 80 km^2. The present estimate is that the Miaofeng Mountain town can carry a maximum of 30,000 inhabitants without jeopardizing the local ecosystem. However, the capacity of the local eco-system defines the limits to increased population.

The present land use and landscape typology consist of four basic groups:

- River valley zones (southern part of the area)
- Hill and mountain slope areas (middle and northern part of the area)
- Villages (located either close to the river banks or in the mountains close to fruit cultivating areas)
- The existing remains of the closed quarries form a man-made new type of landscape which need to be restored in order to support the natural image and high quality of the environment.

Building stock and energy systems

The existing buildings in the Miaofeng Mountain town area have typically brick and concrete structures, Figures V.iv–V.v. Windows are either single or double glazed with aluminium or steel frames. Natural ventilation is common, and new houses have air-conditioning with air-to-air heat pumps.

Figures V.iv–V.v: Examples of modern housing in Miaofeng Mountain town, concrete and brick

Typical heating energy sources are fire wood or coal, and solar hot water heating is also common in new buildings (Figure V.vi). The oldest houses still have wood fired cooking pot on the floor. Flue gases flow underneath stone made beds keeping them warm in winter. The cooking pot is typically the only heat source in these houses.

Most of the houses in the six priority villages are from the 1980s except for Ying Tao Gou which is newly built according to qualified planning and building standards. The building materials are mainly locally produced fireclay brick which has been banned in Beijing from 2002, single-glazed windows, with steel or aluminium frames. New buildings have brick and concrete structures.

Figures V.vi–V.vii: Traditional cooking oven serving also as a heating source for the house and new solar powered houses

Energy systems are based on grid electricity, coal, gas, solar energy and biomass. The main sources for heating and cooking are coal in winter, and liquefied petroleum gas for cooking in summer. The heating systems are mainly stove and radiators with natural circulation. Passive solar contributes to the heating in winter to a certain extent.

New buildings and modern villages have water toilets, but the old villages still have a lot of composting public toilets.

Case study: Miaofeng Mountain town EcoCity

Background and aims

The project produced a concept of an EcoCity to be built in Miaofeng Mountain town in Mentougou District Beijing, and suggestions for implementation of the concept as long-term development. The feasibility study combined the Chinese and Finnish expertise and experiences on sustainable communities. The development bases on the Finnish experiences on production of environmentally friendly materials, buildings and sustainable communities combined with the Chinese technology and local know-how.

The proposed EcoCity area locates in the Miaofeng Mountain town North-West of Beijing City. The area has natural values, and it has been listed as an ecological area. This restricts the use of natural environments to a minimum. The area consists of 17 separate villages with varying number of inhabitants.

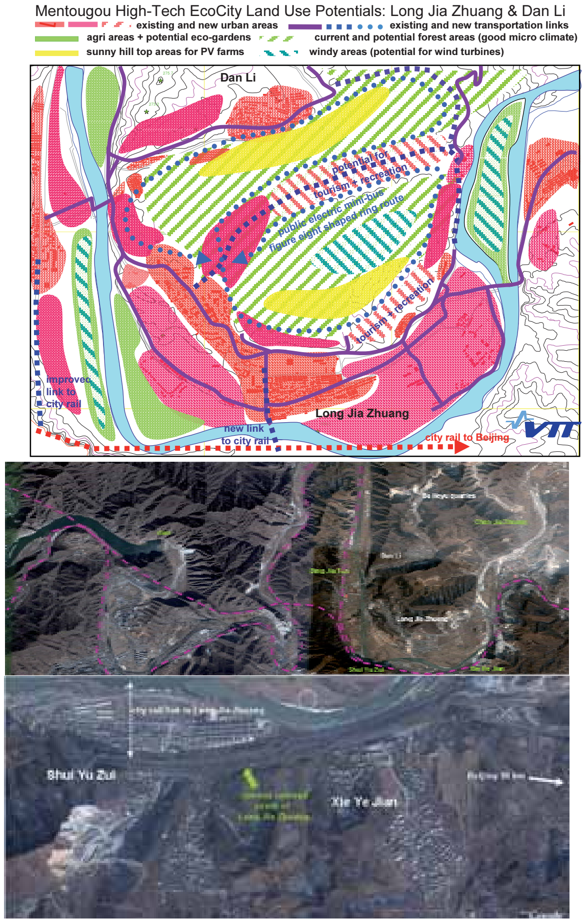
The feasibility study in existing villages

The feasibility study suggests both new villages to be developed to improve the economic structure of the area, and technological and functional ways and means to reduce the environmental impacts of the whole settlement.

The basic properties of the village areas were analysed by constructing thematic maps describing the main features of the selected area. The method was tested in the Long Jia Zhuang and Dan Li village areas (Figures V.viii–V.x).

The study shows that the EcoCity area has various development possibilities. With a view to the future growth estimates of 30,000 new inhabitants, the feasibility study suggest lower rate of growth at least in the short-term. The Northern villages can not be increased due to lack of land for construction without touching the protected green environment around the villages. The main growth should take place in the southern villages close to the connection to Mentougou downtown and Beijing city centre. Railway connection should be improved to Beijing city, as well as other public transport systems to Mentougou downtown.

The southern villages Long Jia Zhuang and Dan Li can be developed for higher amount of new inhabitants, and Ding Jia Tan, Shui Yu Zui and Xie He Jian for lower amount. These villages can carry altogether 10,000 new inhabitants in new low and dense housing areas with area efficiency (floor area per land area) of approximately 0.5 and with maximum of 3 storey houses. This would require about 600,000 m^2 land area by an average housing standard of 30 floor-m^2/new inhabitant. In addition roughly 50,000 m^2 reserved for services is required to fulfil the demands of new inhabitants, corresponding to roughly 100,000 m^2 land use.



Figures V.viii–V.x: Summary of the feasibility study test area in Long Jia Zhuang and Dan Li village areas (thematic map on top). Railroad south of Long Jia Zhuang and the links to the east and west (map in the middle with purple dash lines). A city rail link from Beijing with a station close to Long Jia Zhuang can serve the whole Miaofeng Mountain town area and also tourism. Satellite images by GoogleEarth.

Other villages in the EcoCity area can be developed for minor amount of new housing. Special attention should be paid to renovation of existing buildings and the technical conditions of the buildings. Only buildings with adequate technical conditions should be renovated, and houses in poor condition dismantled and recycled for new construction. Housing services for people living in the houses to be dismantled need to be developed. The old villages need to have some specialties to be interesting for the new inhabitants and tourism. These include finding an individual "soul" for all villages.

The feasibility study in quarry areas

There are roughly 165 hectares of quarries in the Miaofeng Mountain town area. These quarries serve as brownfields for different developments in the area. The process can be described by the two main possibilities and two sub alternatives, landscaping and new construction, Figures V.xi–V.xiv. The possibilities to develop the quarry areas are:

Landscaping

- Restoration & rehabilitation of the old, imitation
- Recovery of old (original) values
- Revaluation of the current situation
- Back to rural (countryside) values

New building construction

- New (added) values on top of old
- Integration of new construction and landscape
- Creative and imaginative, can be even fantastic
- New urban values.

Figure V.xi - Healing the wounds principle aims at covering from sight the consequences of stone mining. This method is applicable, e.g., where the old quarry is utilised as a water reservoir

Figure V.xii - The dotted line describes the mountain slope in present natural condition. The restoration of the excavated steep slopes to artificial natural condition is possible with some shaping of the slope

Figure V.xiii - Artificial structures can help vegetation grow on gentle slopes. This requires cultivation of the ground and additional earth for plantation

Figure V.xiv - New buildings and structures can cover the excavation. These slopes can serve for rain water harvesting

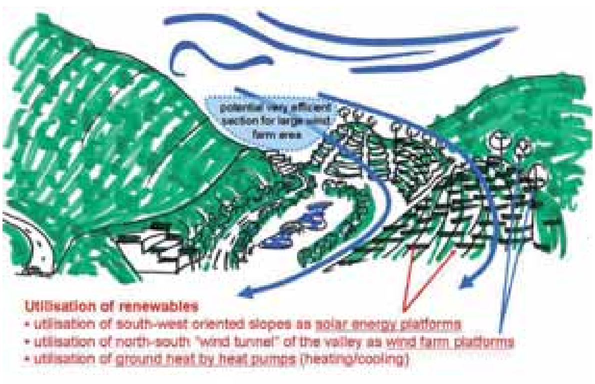
Figure V.xv - View to the Da Heyu quarry. The red lines visualise the mountain shape before the quarry was opened and the amount of soil excavated from the quarry

excavated part (reconstructed/hypothetical)

Figure V.xvi - Illustration of the quarry excavation and a hypothetical new EcoCity housing with daily services replacing the excavated empty space

possible new construction with terraced houses in the excavated part

Figure V.xvi - Visualisation of the possibilities to utilise the geographical, topographical and climatic conditions in the quarry area



possible concepts and types of terraced houses

Figure V.xviii - New housing served by distributed generation of renewable electricity. The terraced houses give a possibility for services such as shops, libraries, day care facilities, restaurants or cafes. Teleworking is possible in common spaces. There can also be a possibility to charge electric cars. Transportation to the building, maintenance and storage rooms are underneath the outdoor areas. Also large covered water storage for rain water harvesting can locate in the basement

Energy-efficient buildings

The heating design temperature for houses with a heating system is -7.5°C, and cooling design temperature 29.1°C. Requirements for good indoor climate in buildings in rural areas define indoor temperatures 18±2°C in winter and no less than 26°C in summer. The requirements for indoor temperature aim at reducing heating and cooling energy demand. These requirements are valid only for relatively new buildings, as the oldest buildings are more than 100 years old. Passive solar heating and cooling choices were analyzed (Figures V.xx–V.xxi).

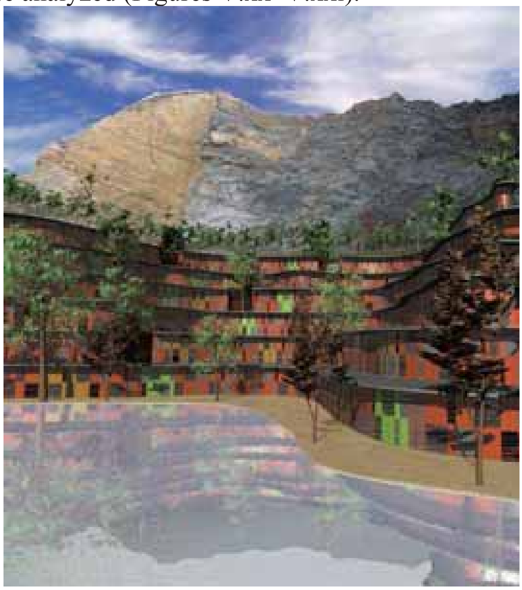


Figure V.xix - Visualisation of the possible terraced housing in the Da Heyu quarry (architects Kimmo Lylykangas, Jari Kiuru and Cillian Warfield)

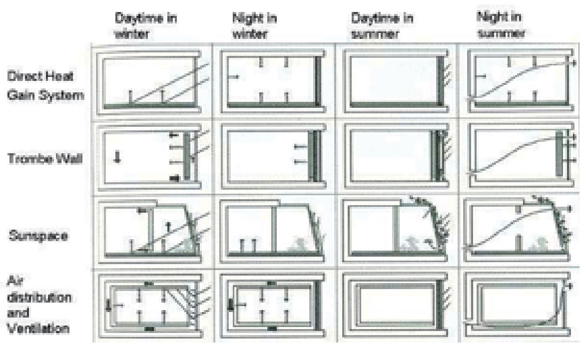


Figure V.xx - Principles of utilisation of passive solar heat for space heating (Beijing Association of Sustainable Development)

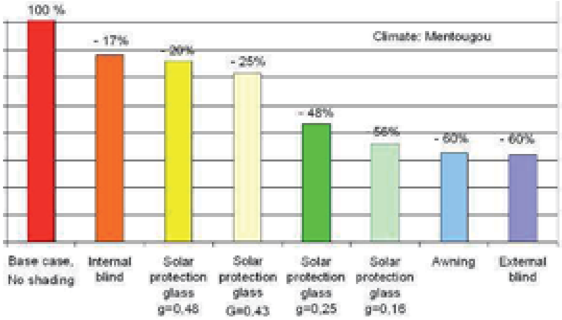


Figure V.xxi - Relative effect of passive cooling strategies in the Mentougou climate

Existing buildings

Building stock in Long Jia Zhuang village serves as an example for whole village level energy-saving. The building typology in the example was clustered into different types of buildings. Roughly 70% of the total floor area is residential and 30% public buildings, workplaces, shops and other services. Total stock of buildings is about 90,000 m³ = 33,000 m². Figure V.xxii shows the calculation parameters for both present stage and low-energy case.

Calculation data	Present	Energy-efficient	Description of measures
U-values, W/m2K - Roof	3.00	0.23	200 mm mineral wool or respective
- Floor	0.60	0.60	No measures
- Wall	1.30	0.30	Additional insulation EPS 100 mm
- Window	2.50	1.20	3-glazed, low-E coating, argon fill
- Door	2.00	0.70	Well insulated or double leaf door
Ventilation - Rate, 1/h	0.4	0.6	Mechanical supply-exhaust
- Heat recovery, %	none	75	High-efficiency heat recovery[1]
Air tightness - Infiltration, 1/h	0.1	0.1	no measures

Note: 1. Possibility to integrate exhaust air air-to-water heat pump for water heating

Table V.i - Parameters in energy analysis. Calculation basis Mentougou, China N 39°47' E 116° 28' GMT +8.0. Population 1 587 inhabitants. The calculation data refers to the information available or suggested data

The estimated (Table V.i) total energy demand in present building stock and after improvements in energy efficiency of Long Jia Zhuang is as follows:

- Energy demands in buildings, present situation (business as usual):
- Heating: 8,500 MWh/a (=257 kWh/m²a)
  - peak: 3.2 MW (=97 W/m²a)
- Electricity: 1,300 MWh/a (=39 kWh/m²a)
  - peak: 0.3 MW (=9 W/m²a)

Energy demand changes in buildings:

- Heating: 8,500 MWh/a -> 3,800 GWh/a (-55%)
  - peak : 3.2 MW -> 1.6 MW (-50%)
- Electricity: 1,300 MWh/a -> 1,300 MWh/a (-0%)
  - peak: 0.3 MW -> 0.26 MW (-13%)

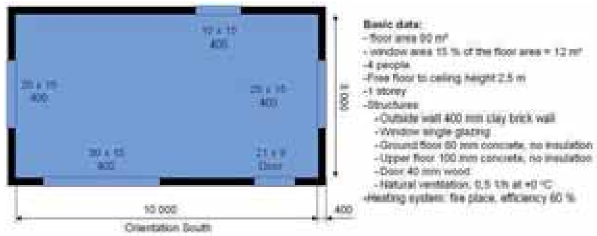


Figure V.xxii - Example house for calculation of heating energy demand

Figures V.xxii and V.xxiii give an example how the energy-efficiency measures affect on the heating energy demand of a detached house. Figure V.xxiv shows the monthly energy demands.

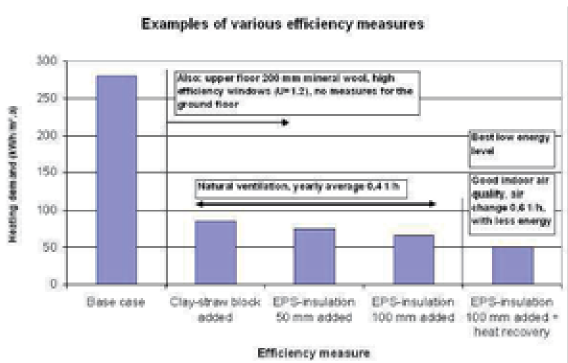


Figure V.xxiii - Different energy-efficiency measures for space heating demand reduction. Clay straw blocks can be produced locally. The blocks are attached to wall mechanically by fasteners of glued with mortar. Façade with plaster including reinforcement net attached to wall

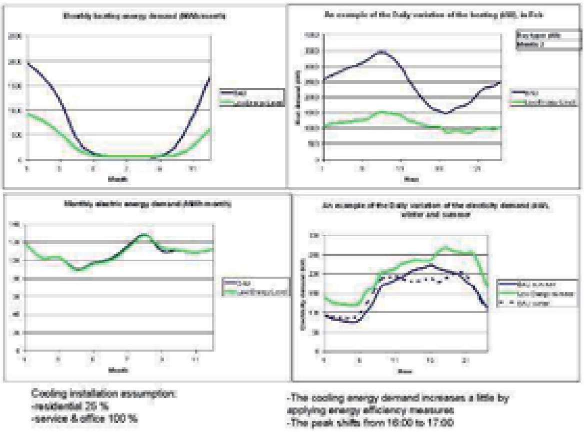


Figure V.xxiv - Monthly heating and electrical energy demand for present and energy-efficiency cases. Passive measures to reduce solar gains in summer reduce the peak demand of electrical energy

New buildings

High density - high rise housing in abandoned quarries can utilise good orientation. The orientation sets requirements especially for cooling demand reduction technologies. The basic performance based energy design features are:

- Combined energy demand for heating and cooling 15 kWh/m^2
- Total energy demand < 50 kWh/m^2
- Airtight building envelope.

It is up to the design team how these design features are met. The requirements base on energy demand without taking into consideration the choice of energy source or HVAC-systems. In general, however, the following design principles can be utilised:

- U-values of walls, roofs and floors: < 0.15 W/m^{2}K
- U-values of windows and doors: < 0.8 W/m^{2}K
- Mechanical supply-exhaust ventilation with heat recovery efficiency > 80 %
- Ground source heating and cooling integrated to ventilation heating system
- Solar shading for windows
- Green roofs for cooling load avoidance
- Water saving fixtures for hot water consumption reduction
- Water metering and apartment or purpose based water tariffs
- Energy-efficient lights, appliances and equipment.

High-rise housing includes mix of uses such as shops, offices, cafes and restaurants. Waste energy flows of these units can be recovered to heating of public spaces in apartment houses or other public spaces. Multi-storey building can also have energy producing lifts that recover roughly 75% of lifting energy by changing the down-going breaking energy to electricity.

Figure V.xxv shows a possible concept for very low energy demand detached house for new housing quarry areas. The house is basically a 1–3 generation house. Building envelope structures are heavy weight for better summer comfort. Internal walls are light-weight for better flexibility of spaces. Kitchen water fixtures are connected to downstairs toilet and technical room module, and upstairs bathroom is on top of the module.

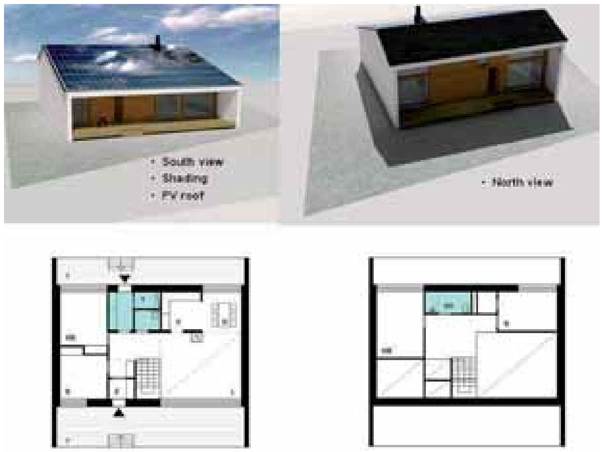


Figure V.xxv - Example of an energy-efficient house concept for new housing areas (Architects Kimmo Lylykangas and Jari Kiuru)

This arrangement reduces the need for installation routing. The features of the house are:

- South orientation and roof slope for efficient active solar utilisation.
- Long eaves for solar shading
- Fire place for additional heating with open living space for heat distribution to upstairs

Passive house standard energy demand.

Conclusions

The heating energy demand of existing housings can easily be decreased by 50%, using structural improvements and ventilation heat recovery. About 80% heating energy reduction is also possible by fully utilising passive house technology in existing housing.

According to present general assumption, the climate change will increase the cooling energy demand. Energy-efficiency improvement has only a minor impact. However, the impact becomes important if the installation of new cooling units continues as business as usual.

When the energy efficiency measures are applied, the indoor climate conditions especially during the summer have to be taken into account. Ground-air heat-exchanger serve as a good passive cooling solution, but the applicability needs to be assessed by ground condition analysis. Active mechanical cooling systems should be avoided, solar shading and other passive systems should be applied in the first place to avoid increase in electrical energy demand.

Production of building materials for the improvement of the existing building stock and construction of new housing locally is rather limited. Simple insulation material such as clay-stray bales or recycled paper based cellulose fibre insulation can be produced locally. However, the cellulose insulation requires energy for crushing the paper into fibrous peaces. Industrially produced materials need to be imported to the area. Recycling and reuse of materials from demolished buildings can be arranged, thus providing employment in the construction. Energy-demanding production of materials should not be established into the EcoCity.

New housing and buildings in new villages need to be extremely energy efficient. The basic building solution is a passive house modification to local conditions. This house type can be modified to an energy neutral or zero-energy house thus providing important environmental values for the EcoCity. The building can be heated or cooled by utilizing only renewable energy sources. Intergrated energy systems chapter considers the energy supply systems of the EcoCity.

New villages should be designed as modular bases to better facilitate energy system design for the EcoCity. These modules can be multiplied according to desired size of the village. The modules are 10 houses for detached housing, and 50–70 apartments and spaces for services for terraced housing in quarries.

Waste management

The source separation and collection system of waste aims at waste management services for a village in the EcoCity of about 2,000 residents. The target is a replicable system which can be implemented in the villages throughout the area. The waste fractions collected from the villages of whole the Miaofeng Mountain town area are transported to a waste transfer and treatment station for further processing (energy and material products) or sorting to saleable materials.

Finding the best practicable option (BPEO) that enables easy sorting and takes environmental, technical, social and financial factors into account is one of the challenges of the project. The results will be adopted into the land use plan showing the sustainable development possibilities for the area. The outcome must be strongly dependent on the local needs of the Mentougou District development.
The waste system should include:

- Modern and easy waste sorting systems for both homes and on municipality level
- Optimised facilities for source separation, transport, and pre-treatment of waste fractions considering the cost, environmental and social aspects
- Optimised waste collection locations
- Future community structure observation (development of waste amounts and composition, development of material and energy costs as well as labour costs, which all have an influence on the feasibility of recycling options)
- Optimization of the role of local people in the waste collection and recycling system for improved employment of the people already living in the area
- If possible, pre-treatment and reuse of the waste near the source, especially increased reuse of the organic biodegradable waste inside the Mentougou area for energy production and soil enrichment
- Development of practices which minimise waste dumping (landfill disposal)
- Maintain and further develop the current practice of collection and sorting of the marketable waste fractions (paper, plastics.)

In all considered system options, waste reduction should be one of the main goals. Minimisation of primary material consumption is usually the most efficient way to reduce the negative impacts of the generation and management of waste. It contributes also to reduction of environmental impacts of whole the resource management chain. In the EcoCity, a sensible goal could be stopping the growth of waste quantities or at least minimising the growth rate. To attain this goal resource effective way of life should be supported by the systems and solutions chosen, beginning from the urban planning. Education and support activities, such as repeated information campaigns, are also required to improve the consciousness of the citizens about opportunities for waste minimisation and resource efficiency.

When considering different options for waste treatment using low-tech, low-cost and labour-intensive waste treatment options should be considered. This applies to all the countries where new waste treatment options are just being introduced. If high-tech solutions are to be used, it needs to be made sure that there are enough competent employees available to run, monitor and control the new waste treatment systems.

Based on above mentioned assumptions as well as waste data from European countries, the waste composition in the village area is estimated to be as shown in Table V.ii.

Waste fraction	Waste generated, estimated			Separation efficiency, target	
	%	kg/resident/a	t/a/village	%	t/a/village
Paper	30	54	108	80	87
Cardboard	5	9	18	80	15
Plastics	12	22	44	75	33
Textiles	2	3.6	7	60	4
Glass	4	7.2	14	85	12
Metal	3	5.4	11	85	9
Biowaste	42	76	152	70	107
Other	2	3.6	7		

Tabel V.ii - Assumed municipal waste composition in a village and the recycling targets for waste fractions

The estimated amount of municipal waste is about 180 kg/resident (360 t/village/a).

Other wastes that need to be treated are:

- Waste electric and electronic equipment (WEEE), the percentage of which is high compared with present situation in China. Further growth of the volume of WEEE, is foreseeable. Based on the European figures an amount of 5 kg/resident/a may be estimated
- Small amounts of hazardous waste
- Varying amount of construction waste (wood, concrete, etc.)
- Biodegradable waste from dry toilets; 70 kg faeces/person/a (140 t/village/a) and about 400 kg urine/person/a (800 t/village/a)
- Sludge from waste water treatment, due to the use of dry toilets the amount of sludge is small (30 – 60 t/2,000 residents)
- Garden waste from plantations
- Animal waste from the surroundings (in a self-supporting system as much food as possible is produced inside the area).

The organic wastes (the dry toilet waste and waste water treatment sludge) may be treated with biowaste at the central waste treatment plant. Probably, a separate collection system is required for the waste from dry toilets. A part of the garden waste from the plantations may be composted near the plantations and reused as soil amendment. The part produced inside the village may be collected with biowaste. A part of the collected food residue (biowaste) may be used for feeding of animals at the nearby animal farms.

The construction waste will be recycled separately. The concrete waste may be used for road construction or even for production of new concrete. The wood waste is assumed to be used for construction purposes or for heating.The collection of WEEE and other hazardous waste will be linked to the collection system of municipal waste.

The following system is proposed for source separation and collection of the municipal waste:

1. Waste is source-separated into several fractions: biowaste, hazardous waste, plastics, paper, glass, metal, WEEE and mixed waste.

   A necessary prerequisite for maximum recycling is a well-functioning and easy to use source separation system. Homes, offices and other buildings are equipped with well-planned waste sorting facilities as well as good waste sorting instructions. Various kinds of home sorting systems with separate bins for all recyclable waste fractions are available. One example is presented in Figure V.xxvi.

Figure V.xxvi - A waste sorting system with separate bins (Stala Oy, Finland)

   Hazardous waste fractions need to be separated from other materials, since it otherwise causes serious damage to the environment. It is important that people in the village understand what kind of waste is especially harmful to nature and source separation contributes to this goal.

2. Source separated waste fractions are transported to the centrally located waste collection points by the residents. To secure a high recycling percentage and good quality of source separated materials, a dense network of waste collection points with as short distances from homes is required.

- For biowaste, paper, plastics, glass and metal one centrally located collection point on walking distance (< 300 m) from buildings. Masterplan of new villages includes these locations (easy to residents, optimal for further transport) is also considered.
- One or two major collection points for other materials (WEEE, hazardous waste, construction

waste etc.) near the daily routes of the residents, for example in the vicinity of shops or other local meeting places, and near the major roads. Local waste management service may also transport the source separated paper, glass, plastics and metal fractions to these major collection points. This labour-intensive service reduces vehicle transport of small waste amounts.

- Pipeline transport inside the village may is an alternative for the proposed system in large and densely populated villages. The major obstacles are the installation cost (20,000 – 30,000 RMB/apartment) and high energy demand (50 kW power demand) Because of the small waste amounts and the decentralized location of villages this alternative is feasible only in new villages built in the quarries or old Sothern villages developed for new residents.
- Use of hygienic deep collection containers, especially for biowaste but also for other waste fractions should be considered. Their use saves space, reduces potential odour nuisances and reduces need of emptying. In a vertical deep collection container about 60 % is underground (Figures V.xxix–V.xxx).
- The recyclable waste fractions types are transported from the major collection points either for treatment or upgrading to the central waste treatment station. The biowaste is collected separately at least twice a week to minimise the odour nuisances, microbial hazards, etc, and used for biogas production. The transport of other source separated materials is optimised based on the filling rate of the waste containers in the major collection points. Waste containers equipped with automatic filling rate identification may be used. In this case, where the waste amounts of whole the area are quite small it may be better to arrange the transport at regular intervals. If desired, the automatic identification technology may be used to ensure that the containers will not be overloaded.

Figures V.xxvii–V.xxviii - Waste deep collection containers (Molok Oy and EcoSir Oy, Finland)

The recyclable fractions are further upgraded to high quality saleable materials at the central waste treatment station. The treatment includes separation of the impurities from the materials, and if required, further separation of some of the waste fractions, dismantling of the electric and electronic materials, etc. Because the waste amounts available from the area are quite small, the most feasible opportunity is manual upgrading. When working with waste, it is important to pay attention to the occupational safety of the workers. Mechanical separation plant may not be an option here due to the high cost of the technology.

The biodegradable waste fractions are treated in the biogas production plant. The residue from biogas production is composted. Composting produces soil enrichment material for farming and restoration of the environment.

Small scale craftsmen's workshops producing high-quality products from waste materials may be located in the villages near the central waste treatment plant. These kind of small shops do not solve the waste problem, but they may help the employment of a few people.

The recycling targets are high compared to best existing systems, and a well-functioning source separation system with high efficiencies is a real challenge. New operational models and new ways of thinking are required. Support activities, such as repeated information campaigns to improve the consciousness of the citizens are probably needed. The most significant pros and cons of the proposed solutions are summarized below (Table V.iii).

Benefits	Potential drawbacks
New employment in the area (waste transport, waste sorting and treatment at the waste transport centre, small craftsmen's shops)	Increased labour costs combined with decreasing prices of the materials may have an negative effect on the economical feasibility of the solution
Revenue from produced energy (fuel), soil enrichment materials, and high quality material fractions produced from recycled waste	Poor quality of the materials may reduce the economical feasibility if the residents and workers are not committed to the recycling
Minimisation of negative environmental impacts of landfill: Reduction of greenhouse gas emissions: - Landfill methane emissions avoided (600 – 1 000 t CO_2-eq/t recycled waste) - Additional benefit from substitution of fossil fuels by waste derived biogas (about 0.2 t CO_2-eq/t biowaste) Reduced production of landfill leachate and odour emissions, reduced landfill space requirements	
Minimisation of the environmental problems caused by hazardous waste disposal into the environment and landfills	
Environmental effects of waste transport minimised by optimisation of the collection and transport system and by treatment wastes near the production locations	
The functioning of the system (high recycling rates, good quality recycled materials to sale, waste minimisation, as well as use and maintaining of the waste treatment facilities demands high commitment of residents and all the local parties	Support activities (education and information campaigns, etc.) needed during the first years, and probably even later

Table V.iii - Benefits and potential drawbacks for suggested waste management systems

Water and waste water systems

Water is a critical issue in the planning and realisation of the EcoCity. There is little or no surface water in the area and groundwater resources are limited and, apparently, over-exploited. Figure V.xxxii give examples of water management and current problems in three of the priority villages.

Water sufficiency is a challenge, especially as the annual precipitation in the area has been noticed to decline in recent years. The annual water consumption in the three example villages is between 15 and 40 m^3. The highest consumption is in Jian Gou village located high in the mountains close to Miaofeng peak. The village is a touristic attraction (Miaofengshan temple) which has a direct impact on the water consumption.

Long Jia Zhuang				
Water source	**Water consumption**	**24 h consecutive water supply**	**Drinking water treatment**	**Water supply**
Groundwater, 2 x 350 m wells	36 - 48m^3/year and household	Yes	No	Rebuild 2003, plastic pipe
Hot water	**Wastewater**	**Seasonality**	**Wastewater collection**	**Treatment process**
Some solar water heater	Domestic and industry wastewater	No	Sewage collection pipe network	Centralized treatment
Toilet type	**Rain**	**Rainwater collection**	**Industrial types**	**Surface water**
Public, no water lavatory	Rainfall reduced in recent years	No	Land lease, fruits, small industries	Yong Ding River

Dan Li				
Water source	**Water consumption**	**24 h consecutive water supply**	**Drinking water treatment**	**Water supply network**
Groundwater: 2 x 300 m wells	30 m^3/d	No, one hour at noon in a day	No	Rebuilt 2006, plastic pipe
Hot water	**wastewater**	**seasonality**	**wastewater collection**	**Treatment process**
Some solar water heater	Domestic sewage, industry wastewater	No	Sewage collection pipe network	Centralized treatment
Toilet type	**rain**	**Rainwater collection**	**industrial types**	**surface water**
Public, no water lavatory	Less rainfall	No	Tourism, fruits, small industries	Yong Ding River

Jian Gou				
Water source	**Water consumption**	**24 h consecutive water supply**	**drinking water treatment**	**water supply network**
Groundwater, 2 x 250 m wells	50 m^3/d, 100 m^3 water reservoir	Yes	No	1973, cast-iron and plastic pipe
Hot water	**Wastewater**	**Seasonality**	**Wastewater collection**	**Treatment process**
Some solar water heater	Domestic and food factory wastewater	Tourist season May - October	Sewage collection pipe network	Centralized treatment
Toilet type	**Rain**	**Rainwater collection**	**Industrial types**	**Surface water**
Public, no water lavatory	Less rainfall	Water cellar	Tourism, flower and fruit processing	Flood channel

Table V.iv - Water and wastewater management in Long Jia Zhuang, Dan Li and Jian Gou (data by Beijing Association of Sustainable Development)

The new villages in the quarries aim at high-end housing, which suggests higher than typical water consumption compared to other villages. With 2,000 inhabitants in a new village, the total annual consumption estimate varies from 66,000 to 91,000 m^3. The first number corresponds to the amount of water needed for a comfortable but water-saving lifestyle, and it is on the same level as the maximum water consumption in the existing villages (in Jian Gou) in the area. The latter number is approximately the amount of water used by a resident in a European household (125 litres pp/d: 5 litres drinking water, 60 litres shower, 30 litres to toilet, 30 litres for other). In addition to these numbers, public and daily services, tourism and possible industry require water.

Water saving must be taken into account at every stage and in every aspect of the planning and realisation of the EcoCity. Therefore, it is suggested that the EcoCity development should avoid businesses and production that use water, such as increased agriculture in the mountain area. Domestic water use should base on water saving fixtures and appliances (e.g., shower heads, washing machines).

Groundwater should be used to a limited level, preferably only for drinking, cooking and using a dishwasher to save the declining groundwater levels. The estimated ground water demand is 10 litres per person and day. A water supply system needs to be built to supply the village with service water for showering, laundry etc. The demand of secondary water is estimated 85 litres per person and day. Since there are no other water sources available, rainwater harvesting must be introduced everywhere in the area.

The rain water harvesting surface is roughly 75 m^2 per each resident to cover the demand of 85 litres/day provided that the rainfall is at least 400 mm a year. To cover the whole demand throughout the year, a family of three needs a water storage of at least 60 m^3. Since 70% of the rain falls between June and September, the rainwater tank is mostly full during those months.

Rainwater can be harvested from the rooftops and can be used for washing and even drinking, if treated properly. The principle of the system is given in the Figure V.xxix. The rooftop collection has the most potential for rainwater collection, as the collection surface (the rooftops) does not need to be built separately. Rainwater flows to water storages in every house during the rainy season and used during the drier time of the year.

Roof with continuous guttering can be of different material like steel, brick or concrete tiles, or slate. The water proofing material can not contain toxics or water soluble harmful compounds. Green roofs tend to absorb water and they are not suitable for rainwater harvesting.

The first rainwater flush contains dust and particles that need to be either filtered (e.g., sand filter) or directed away from the harvested water. The system may require a pump to serve the water to the house's water system. The quality of the collected water needs to be ensured both by keeping the collection surfaces (the rooftops) clean and by treating the water before use. This could mean a combination of different filtration methods (sand filter, carbon filters etc.) and possibly disinfection that can be performed with chemicals, UV radiation or other methods.

In addition to the rooftop collection system, a reserve water supply system should be considered for the times when the annual rainfall is less than 400 mm (as it occasionally has been). This could be a combination of a water reservoir in the mountains and even well water. During the years with very little rainfall even water consumption may need to be lowered. Since the rainfall is distributed unevenly in the district, rainfall sufficiency must be ensured when planning the housing.

Figure V.xxix - Rooftop rainwater harvesting system (Figure: Beijing Association of Sustainable Development

Figure V.xxx shows a schematic picture of a water storage that can be used for drinking water production as well. In this system, drinkable water requires chemical treatment, or use of osmotic film purification.

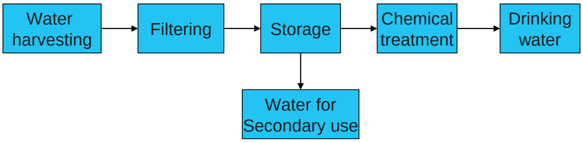


Figure V.xxx - Water system based on large storage

Water can be collected into reservoirs in the mountains or in the valley (using a hillside run-off collection system). Quarries are possible mountain-side run-off collection areas. Larger scale collection is also possible (see Figure V.iii), with substantial construction in the greenfield areas. Water collected to storages or reservoirs needs to be pumped to the villages. The hillside and mountain collection systems could function as a reserve water supply system during the driest years.

Rainwater harvesting requires large collection surfaces and storage tanks, and thus it is difficult to cover the water demand with rainwater harvesting. Large harvesting areas can be connected to large reservoirs, e.g., in the quarries. The reservoir should be covered from light to prevent light caused bacterial attack. A storage mined into the rock would decrease the temperature of the storage, thus reducing the bacterial attack further.

A large storage above (50–80m higher) a village would also provide suitable pressure level for the water supply system. A pressure drop station serves for a typical water supply system pressure level enabling, e.g., use of washing machines.

The grey water coming from the bathroom, kitchen and laundry contains contaminants respective to the wastewater origin: nitrogen, phosphorous, organic matter and even microbes, but less than sewage in general. However, the amount of nutrients and microbes can be surprisingly high. The water treatment for recycling must reach a very high standard. An essential part in efficient wastewater treatment is the use of 100% biodegradable detergents. The grey water system cannot accept any toxics but only substances that can be decomposed by micro-organisms.

The treatment process needs to be chosen according to the quality of the water and treatment conditions. Since the villages have a cold winter, not all local solutions for grey water treatment are applicable. Low-tech solutions that need little maintenance should be preferred. If a local solution is applied, it could be a combination of septic tanks, carbon and sand filtration, biofilters and disinfection. In a treatment plant an activated sludge process combined with filtration and disinfection could be one possibility. One alternative is to use an organic process for treating the grey water. These types of solutions are already in use in China, Figure V.xxxi.

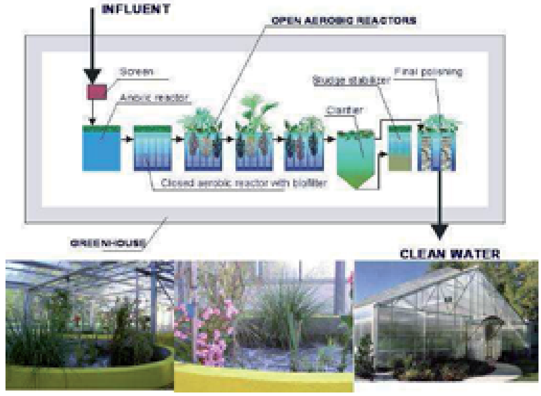


Figure V.xxxi - System for organic treatment of grey water (Beijing Association of Sustainable development)

Grey water treatment system can cover a whole village. Also systems serving only a few houses exist. High-level purification results can be reached even with a decentralised treatment system. A centralised village based system is economically more feasible. A local treatment plant has the benefit of easier monitoring of the water.

In case the area has a lot of storm water flowing on the streets during the rainy season, a separate storm water park can be built to collect and treat storm water. In a storm waterpark the water can be treated in a constructed wetland before it is released into the river or another water system. This prevents the contaminants from the streets from coming to the water systems.

Sanitation

The new detached housing areas should have dry separating toilets in order to avoid wasting of water. Both non-separating and separating dry toilets are possible options, since sometimes the use of separating toilets has been considered difficult. Having dry toilets not only saves remarkable amounts of water but also brings other benefits. There are a number of dry separating toilet models available, Figure V.xxxii. A dry toilet can look like a normal water closet. Basically, each toilet bowl has two compartments: one that catches urine and another that catches faeces. The treatment of dry faecal matter and urine depends on the model.

Figure V.xxxii - Bathroom with a modern dry toilet

In a separating toilet urea and faeces are collected separately in order to prevent cross-contamination; urea is a valuable product that can be used as a fertilizer, whereas faeces contain the vast majority of microbes within human waste. Urea contains a high number of nutrients and is therefore an effective fertilizer. The collected urea needs to be stored from one to six months in order to ensure that the microbes contained in it have died. However, if separation from faeces is not complete, the urea must be stored for at least six months or even for a year. Collected urine can be stored onsite in underground tanks made of bricks and cement, and reused for agriculture e.g. at the plantations surrounding the village.

Faeces are collected separately, after which they can be either composted or fermented. Co-fermentation with other organic waste such as food or crop residues should be preferred, since it offers a possibility to energy production. The end product of both processes can be used as soil amendment, however, the fermented product has a higher quality. Fermentation also has the benefit that the by-product of the process, biogas, can be used to replace other fuels and thus save the surrounding nature.

Anaerobic digestion (or fermentation) needs a temperature of at least 10°C in order to function. Typically, a large size digester operates either at 35°C or 55°C. Some of the produced energy is needed for heating the reactor unless another heating method such as a solar heater can produce enough heat to keep the process at the right temperature.

There are many benefits involved with the use of dry separating toilets. In addition to gaining fertilizer and soil amendment, money and of course water can be saved. When dry toilets are used, there is no need for a centralized system for treating black water. This means savings in pipeline construction and maintenance costs and a dramatic drop in wastewater treatment costs.

Conclusions

The water management in the Miaofeng Mountain town should base on large-scale rain water harvesting and storages. The rock in the storages needs to be injected for better water tightness, and possible harmful emissions from the rock or injection substances need to be assessed. Rainwater can be purified to drinking water level by chemical treatment or osmotic film purification. Secondary water requires efficient filtering to suit for other purposes such as washing.

Groundwater use should be very limited as the water level has decreased. Due to lack of water, water use for irrigation should not be increased. Therefore, agriculture should not be expanded in the mountain area. The preliminary source for irrigation water should be gray water recycling.New detached housing areas should have dry toilets to save water. Water-saving is also the basis for selection of water fixtures.

Agriculture

Agriculture is one of the ways to a self-sufficient EcoCity. Agriculture design is an important characteristic of Miaofeng Mountain town EcoCity, as it faces the main problem of the area – water insufficiency. Local food production reduces the community’s dependency on industrial systems of food production and distribution. Agriculture is also one of the traditions in the area, and as such it plays a role in helping to develop an alternative model for suburban living with a healthy and socially rich lifestyle. Agriculture ameliorates local micro climate, enhances the ecological carrying capacity and offers convenient choices to enable residents to live healthily.

The Miaofeng Mountain town has many famous agriculture forms with substantial economic profits. Based on this background, the agriculture design will develop further to search for more ecological and social profits, with primary three forms: non-profit educational organizations, city farm community, modern molecule agriculture. The first two parts are non-profit, and the yield food is for the local community and donation to the poor old people in this region. Although they are nonprofit, as a unique characteristic they could broaden the influence of EcoCity, and make the profit sectors achieve more success.

City farm can produce fresh and organic food to the EcoCity residents, tourists and visitors. Agriculture development can result in an associated farmer's markets for distribution of products. Locally available food reduces the need for packaging and transportation significantly, making life in the EcoCity more energy efficient. The city farm community can establish great integration and harmony with the inhabitants, and such a structure reaffirms the links to ancient Chinese farming.

The location of non-profit educational organization overlaps with city farm community. In addition to providing local food to inhabitants, City farm community itself is a school that performs in ecological balance. The whole agricultural structure aims at transparency in the food chain: where the food comes and where the produced food wastes go. The farm community can play a role of education by telling tourists, visitors and students the basics of sustainable agriculture and showing the possibilities of clean food production.

The idea of Molecule Farming (MF) is to realize self-sustainability in material and energy. Molecule farming in the EcoCity can help to increase the buse of biomass in energy production. However, the basic sources in molecule farming, such as algae, are not eligible in the EcoCity due to water shortage and needs to manage water resources very carefully.

The agriculture in the EcoCity can be divided into two structure categories: traditional sustainable agriculture and industrialized agriculture. City farm and educational organization are forms of sustainable traditional agriculture, while molecule farming will have industrialized structure (Figure V.xxxiii). Traditional agroecosystems are the only time-tested examples of sustainable agriculture that exist today. For example, traditional agriculture in China's Tai Lake Region (Figure V.xxxiv) sustained high productivity for more than nine centuries. Still, the net farm income increased over time, as a result of increased multiple cropping and the intensified use of organic fertilizers. In the EcoCity, structure of the traditional sustainable agriculture will be designed in the agriculture system. MF is more close to a kind of industry, as it is in intensive form and the high-tech play a far more important role in its development.

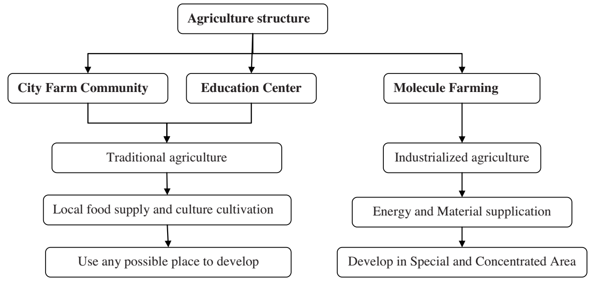


Figure V.xxxiii - Agriculture structure

Figure V.xxxiv - Traditional agriculture (Photo: Mentougou Science and Technology Office)

Agriculture has close relationships with the ecological restoration, cultural cultivation, water system and waste management system. In order to achieve sustainable fertility on a closed system basis, the farms will fully use composting coming from waste recycling, while allowing farmers and gardeners to retain more of the land in a wild state without any pollutions coming from fertilizer and pesticide. Also, by linking different elements of farm community and different local process, by-products and waste generated could be reduced effectively.

Lotus flower wetland has an integrated role in the City farm community: water treatment, cultural cultivation, and food production. According to history documents, Lotus flower as one of the most popular flowers in China has grown for at least 7 thousand years and span almost all over the country. Lotus Flower is useful for wetland water treatment process. Lotus flower can be used in the water treatment process by filtrating of rainwater.

Conclusions

The water management should drive the location of agricultural. Sustainable land use and water management suggest that agricultural development should take place close to the river, while existing agriculture can be upgraded close to the villages. The location planning of agriculture system can fully use the space beside the built architecture and infrastructure, or even use the roof of buildings. The precondition for agriculture development in the mountain area is that local grey water recycling allows for irrigation water and thus more cultivation.

Transport systems

EcoCity transport services aim at high-class, well performing and appealing public transport with equal transport services to everyone. Transport services are connected to community development allowing for a car independent life-style. Mix of uses in an EcoCity is a planning requirement.

The objective for traffic planning is to decrease negative effects to environment. The basic element of an EcoCity is a minimized use of private cars. Therefore, the priority is in planning of walking, cycling and public transport. The development bases of the transportation system are:

- Accessibility to services,
- Safety and health,
- Social sustainability by ensuring mobility for all traveller groups,
- Regional and urban structure,
- Zero-emission and bio-energy vehicles for transport,
- Low environmental impact by utilisation renewable energy resources,
- Efficient and economic systems for transport of goods, delivery, collection and maintenance.

Urban structure and land use should minimize the need to travel and allow for living without a car by availability of daily services in a housing area. Compact land use aims at locating housing quarters, businesses and services close to the routes of public transport services. In the new housing areas, delivery to shops, restaurants, offices etc. can be arranged using underground spaces in order to calm the surface.

Effective and attractive public transport bases on user demand and easiness of services. In an EcoCity, all citizens should have equal mobility possibilities. Planning of transport system is based on multimodality. The EcoCity residents and visitors can have parking places for bicycles at public transport stops and especially at the railway stations. Tourists can rent bicycles at the station. Public transport with low-emission or totally emission free busses inside the EcoCity bases on service lines connecting the villages. Special dial-a-ride lines can serve elderly and handicapped, and tourism.

New light-weight electric cars suit for taxis in the EcoCity. The capacity of these cars is driver and 2–3 passengers. The waste management in the whole Miaofeng Mountain town can connect to public transport. Anaerobic digestion can produce gas for fuel to busses. Service traffic will be allowed in the EcoCity.

The EcoCity can have a car club, car share service, with zero-emission cars. The aim is to reduce car ownership. The cars may be used in the city and transport to Mentougou centre and Beijing City. ICT based rental system allows for delivery and pick-up services for the cars to and from special parking places at the underground spaces of the new housing areas.

Mobility management for public transport (both internal and external) is supplied with mobile real time information and services including timetables and booking. The system can cover intelligent payment services, and car sharing. It also helps the residents and visitors to receive information on disturbance in public transport, but also on walking and cycling. Internet or mobile phone services' providers and shops, restaurants, hotels etc. can sell public transport tickets in the area.

Transport connections to and from the city are frequent and function fluently without congestion. In the future, the Miaofeng Mountain town connects to Mentougou centre and Beijing city via a train link. Especially domestic and international tourism requires a city rail link from Beijing to Miaofeng Mountain town. This link can utilize the existing railroad connections (see Figures V.viii–V.x), and new transport services (taxi, busses) from, e.g., Ding Jia Tan, Shui Yu Shui, or Xie He Jian to Miaofeng Mountain town amenities. Public transport inside the EcoCity link to the train services at the stations.

Parking places for private cars locate at the railway stations and public transport terminals. These parking areas need to have a suitable capacity for tourist cars, and a limited number of private owned motorized vehicles. Parking should be subject to a parking charge for organization of parking management.

Conclusions

Transport in the EcoCity bases on well-organised public transport. The EcoCity connects to Beijing City and Mentougou Centre via a train link. Inside the EcoCity service traffic is allowed, but there are no private cars. Car sharing and dial-a-ride services with electric or gas fired taxis and buses serve for both residents and tourists. Bus routes connect all the villages. Pay parking for private cars locate close to railway stations and public transport terminals.

External freight transport (import of products and raw materials, and export of local products) is centralised through distribution terminals at the outskirts of the EcoCity area.

Integrated energy solutions

Design of energy utilization in the EcoCity bases based on integration of system energy flows inside one single balance area, the EcoCity. Heat and electricity flows in and out of the balance area are estimated separately, and all of the available resources inside the balance area are utilized to meet to required demand. If the balance area cannot supply needed energy, more energy should be supplied outside of the balance area. The optimisation of the energy systems requires iteration between system design and land use planning prior to calculating and optimizing the intended mass of the buildings.

In the EcoCity energy system design, *first* step of the design is to determine the energy consumption inside the EcoCity area. The buildings should be low-energy, passive or zero energy houses. Communal services and public transportation should be efficient and well covering. Efficient waste management system is required with high levels of recycling and waste utilization in energy recovery. Energy consumption should be minimized, even if energy is produced from renewable sources. Reuse and recycling should be encouraged in waste management. Waste incineration and energy production is final option, while land filling is not an option.

Second step of the design is to determine the available energy resources. These resources include renewable and non-renewable direct energy sources such as solar, wind or biomass, and indirect energy sources such as municipal solid waste and collected rainwater. Non-renewable energy sources should also be considered, because bulk of the existing energy production capacity is conventional non-renewable. Designing EcoCity to be totally self-sufficient should not be an absolute value.

The *third* design step determines production and demand variations inside the balance area. Energy consumption varies daily, weekly and monthly, but still energy and heat supply must be stable for the end users, e.g., in buildings. Heat and electricity are primarily produced from renewable sources. Solar and power are the most prominent renewable energy sources in large scale utilization because either wind, solar or both exist in most of the inhabited places around the globe, Figures V.xxxv and V.xxxvi.

Biomass can be used when the amount of needed energy is equal or less than the renewal of renewable biomass resources in the region. In addition, more specific emission-free resources can be used locally, such geothermal energy. Solar and wind energy production has great hourly, weekly and monthly variation. Peak solar production is during summer, and peak wind production is during winter.

Combined wind and solar system has lower variation over the year than simply solar or wind system, Figure V.xxxvii. When varied consumption and varied production are combined in one system, it is clear that the total regulation demand of the energy system is high.

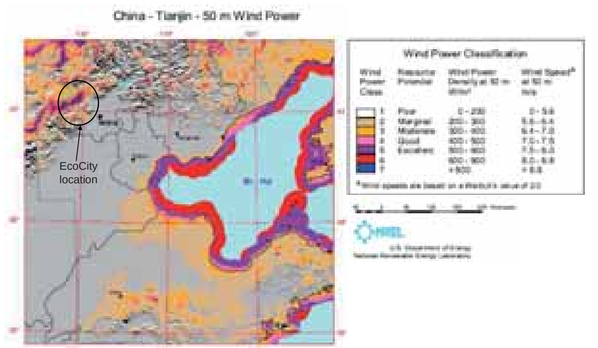
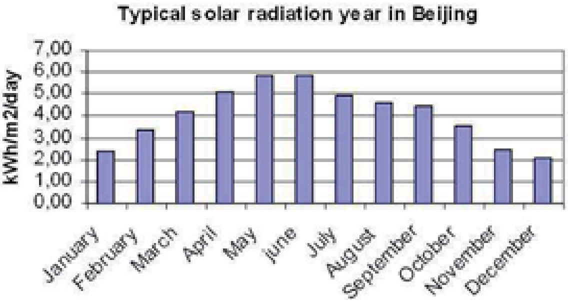


Figure V.xxxv - Wind power estimates for the EcoCity location. (Source: U.S. Department of Energy. National Renewable Energy Laboratories)



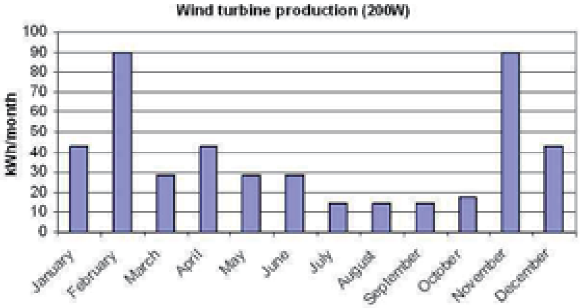


Figure V.xxxvi - Estimated solar and wind energy production variations by month. (Source for solar radiation year: Zhou, J. et al. Renewable Energy 31 (2006) 1972– 1985)

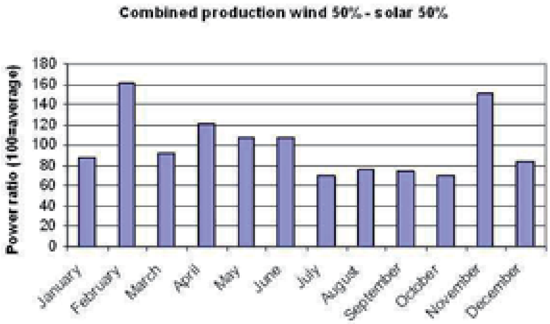


Figure V.xxxvii - Combined solar and wind energy production

The basic principles of waste management in the EcoCoty are waste sorting and recycling. Therefore, the residual amount of community waste for waste incineration is very low in the whole EcoCity. As the energy content of municipal waste normally varies between 1.5–4 kWh/kg, (depends on the biodegradable and inert content of the waste), and the efficiency for a typical waste incineration plant can be as low as 20%. Mass burn incineration is not an option in the EcoCity, and more sophisticated systems such as gasifiers are not feasible for such a low amount of waste.

Anaerobic digestion can process biowaste to methane. The energy content of methane gas is roughly 10 kWh/m^3. Methane serves as biofuel the public transport schemes in the EcoCity. Table V.v shows the potential of different biowaste fractions.

Source	Methane production potential, m^3/ton-wet weight
Fat (theoretical)	1,014
Proteins (theoretical)	504
Carbohydrates (theoretical)	415
Slaughterhouse waste	150–200
Municipal biowaste	100–150
Energy plans (molecule farming)	50–80
Manures	9–12

Table V.v - Methane production potential from biowaste (Kalmari2006)

The EcoCity energy demand is covered mainly by self-sufficient system, which draws energy from local renewable sources. In Miaofeng Mountain town, main renewable sources are solar and wind. Some biomass might be available from the farms and possible molecule farming activities. Waste to energy systems with biodegradable waste and human waste can be utilised. Also, altitude difference in the mountain area can be exploited in energy production or storage.

Most of the electricity needed in the EcoCity area can be produced by solar power or by combination of solar and wind power. Wind power potential in the Beijing area is not great; however, Miaofeng Mountain town locates west of the Beijing, and has higher wind potential. Regardless of the chosen concept, electricity production, which is based on solar and/or wind, requires high level of power regulation and backup power.

There are two ways to cover *production regulation* need: Self-sufficient system and grid connection. Self-sufficient system requires the use of all available resources in the electricity regulation and backup power production. Biogas from anaerobic digestion of biodegradable waste should be stored and used in gas-engines or fuel cells when main power system (solar and wind) is not sufficient.

Some electricity can be produced by large-scale rainwater harvesting systems located up on the mountains. Rainwater collectors can be used as reservoirs, which store energy in the form of water. During high load, water can be discharged to produce energy by micro-turbines. This concept can even be further improved to let rainwater collectors or water storages function as a pumped storage for solar and wind production regulation. During the peak production in day time (when the solar energy production is at its highest), some excess energy can be used to pump water up to the mountains into the storage tanks.

Later, when production from main system cannot cover the energy need, or when high level of regulation is needed, water can be discharged for energy production. The reservoirs can be combined water storages for human needs and energy production. The reservoir sizes would be very large, only for human needs in the order of magnitude 100 000 m^3, Figure V.xxxviii.

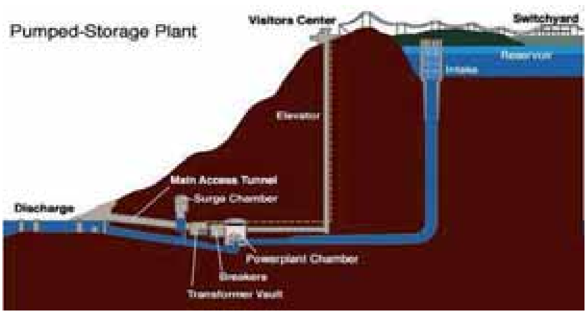


Figure V.xxxviii - The principle of a pumped storage system. If the reservoir serves also as a storage for water for human use, the reservoir should be covered)

Grid connected energy system would grant extra degree of freedom for system design. Grid connection would provide the needed hourly regulation to cover production variation from wind and solar farms. Also during high demand season during winter or mid summer, peak load could be supplied from the grid. During peak production period, excess electricity could be sold to customers via main grid.

In the EcoCity, solar collectors can provide the main heat source. The problem with the installation is the negative correlation of peak demand and peak production. If solar heating system is designed to cover peak loads during winter, total efficiency would be low. However, if the system is designed to meet average load, some heat must be supplied from other sources. Other sources might include solutions such as heat storages, micro-CHP which uses biogas from anaerobic digestion plant, or heat pumps. Geothermal heat pumps can serve for two needs, heating in winter and cooling in summer.

In order to fully optimize the energy system inside the EcoCity area, all the other systems which are in some way connected to energy use and or production need to be covered. These are waste management, water management, transport and agriculture.

Biodegradable waste can be treated in an anaerobic digester. Anaerobic digestion produces biogas and nutrient rich-solids which can be used on the local farms. Biogas can be utilized in several sectors in the EcoCity area. Gas can be used in gas-engines to produce electricity and heat, or it can be used in kitchens instead or mixed with natural gas.

Biogas can also be used in transportation. Biogas vehicles could be visible municipal vehicles like school bus, waste collection vehicles or city car club vehicles. A visible implementation of renewable biogas produced locally would perfectly promote the idea of EcoCity among the residents and tourists. Also, if biogas generation could be extended further to cover more area in Shijingshan district or in Beijing downtown, large scale utilization of biogas could be implemented in the EcoCity area.

Water shortage requires water savings and water collection from other places than groundwater or nearby surface water bodies. In order to fully optimize this system, rain water collection can be integrated with energy system. Rain water can be collected in higher altitude on the mountains, and then discharged down to villages. This altitude difference can be used to produce electricity by micro-turbines which are installed into the water pipes. More sophisticated solutions could include pumped storages, where collected water can be circulated back to storage tanks. Water can then be used to regulate power production and limited energy production can be compensated during peak loads.

In transportation local vehicles could run without fossil fuels. Substitute energy sources would include locally produced biogas and electricity. Local public transportation would include trams or electric buses etc. Biomass from the farms (possible from molecule farms) could be used in gasification or combustion. However, this solution requires a constant supply of moderate amount of biomass. At this state, it is unclear if there is enough biomass available in the EcoCity area, or near it.

EcoCity concept consist unit blocks of 10 single-family houses or larger terraced house complexes. Group of 10 houses and terraced house are considered to be practical and economical scale for smart system implementation. Both house types are rated for four persons. Single-family house (villa) area is 150 m^2 and terraced house apartment area is 115 m^2. Rated value for domestic hot water demand is 900 kWh/person/year, space heating 10 kWh/m^2/year, cooling 5 kWh/m^2/year, and 3,000 kWh/year for household electricity. All houses are state-of-the-art low-energy buildings.

Demand	Person kWh/a	Household kWh/a	Buildings kWh/m2/a	Villa kWh/a	10 villas kWh/a	Terraced houses 50 apartments kWh/a
Hot water	900	-	-	3 600	36 000	180 000
Space heating	-	-	10	1 500	15 000	57 500
Space cooling	-	-	5	750	7 500	28 750
Electricity	-	3 000	-	3 000	30 000	150 000

Table V.vi - Simulated energy demand of modules of 10 houses and terraced house with 50 apartments

Heating system bases on small scale central heating driven by combined solar heating – geothermal heat pump cycle. In one group of 10 houses, heat pump and heat storage is located in the middle of building group. Concentrated solar heating system is installed on the roof of the houses. In terraced houses, heat pump and storage is located into the maintenance space. Solar panels are located on the roofs and walls. Domestic hot water is mainly produced by solar heating system, which is integrated to heat pump driven storage tank. Space heat and cooling is supplied by high efficiency geothermal heat pump. Extra heat and cold are stored into bedrock via heat wells. Geothermal heat pump charges the heat wells to store energy to comply with seasonal variation.

Interior heating and cooling, as well as domestic hot water is supplied from one large heat storage instead of several single-house storages. Concentrated solution provides savings in investments, and heat losses are lower. Another option is to build heat tanks and solar collectors separately in every house in the group. In this solution, space heating is produced separately in every house, and heat pump is only used for hot water heating. This solution is easier to complete, but less effective.

Conclusions

Electricity in the EcoCity is produced by solar photovoltaic system combined with wind power. Due to lack of appropriate wind data on the EcoCity site, wind system cannot be designed with proper accuracy at this phase. As a rule of thumb, 100 kW wind power installation produces 200 MWh of electricity. Power regulation bases on grid connection.

Electricity is used to drive heating/cooling system (heat pumps). PV-system production should be maximised by optimum inclination of 30–45 ^{o} south oriented panels. The maximum efficiency of high–efficiency commercial PV panels is today 17%, allowing for an electricity production of about 200–250 kWh/panel-m^2. Local house based short-time power regulation is provided by battery system which is located at the pump station with heat pump and heat storage. Intelligent grid connection enables continues electricity supply.

Main grid provides seasonal power regulation as well as auxiliary power and reserve power. PV-system requires a relatively large land area if installed as a single solar array system. The whole estimated land use for a PV system for 10,000 residents is roughly 10,000 m^2. It is feasible to integrate the most of the PV systems into buildings because PV-panels can mainly locate on the roofs and walls of the buildings.

Table V.vii shows the required photovoltaic panel and sizes wind power capacities for building modules if the electricity production bases only on PV or on PV and wind. PV system covers electricity demand through the year. In larger scale design, it might be feasible to construct larger solar-wind parks near residential areas to cover municipal and residential energy need.

Supply	10 villas unit			Terraced house		
	Heat pump electricity	Solar heat	Electricity	Heat pump electricity	Solar heat	Electricity
Hot water, kWh/a	3 150	23 400	0	15 750	117 000	0
Space heating, kWh/a	3 750	0	0	14 375	0	0
Space cooling, kWh/a	1 500	0	0	5 750	0	0
Household electricity, kWh/a	0	0	30 000	0	0	150 000
Total demand, kWh/a	8 400	23 400	38400	35 875	117 000	185 750
Peak demand, kW			16			70
Total heat well depth, m	700			3 000		
Solar collector area, m^2		40			215	
Alternative 1: only PV - PV area, m^2			180			900
Alternative 2: PV - wind - PV area, m^2 - Wind capacity, kW			90 15			450 46

Table V.vii - Required solar thermal collector sizes, PV panel sizes and required wind power capacity if the electricity production bases on only solar, or on solar 50% - wind 50% estimation

Table V.vii features the energy systems for new residential areas. Municipal and services' energy demand increases the required production capacity by 50–100% and the required installations accordingly. Due to the environmental values of the Miaofeng Mountain town, all energy production should be integrated into brownfield areas as in the examples in Figures V.xxxix–V.xli.

Figures V.xxxix–V.xli - Energy systems using renewables and integrated to buildings and built environment (Lahti et al 2006 and 2008, Dunster 2008)

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VI Germany

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National context

Germany is a federal, parliamentary, representative democratic republic in the centre of Europe. It is the seventh largest country by area in Europe with Berlin as the capital and the largest city as well. Germany consists of sixteen states, each of which has a district government and a constitution of its own, which means that the republic and the state governments are able to legislate in their area of authority. Each state has a building regulation with the requirements for a construction.

Germany was a signatory nation of the Kyoto Protocol, in which the industrialised nations made a binding commitment to reduce their combined emissions of six greenhouse gases - including carbon dioxide (CO_2) – by 5.2% in the period from 2008 to 2012 compared with 1990 levels. Germany committed itself to a reduction of 21%. Currently (2009), emissions have been reduced by 19%. The German Government is aiming to reduce CO_2 emissions by 40% by the year 2020 (compared to 1990 levels).

The Energy Saving Ordinance (Energieeinspar-verordnung) is a German regulation aimed to reach the climate targets for buildings.

Climate

Germany has a temperate seasonal climate in which humid westerly winds predominate.

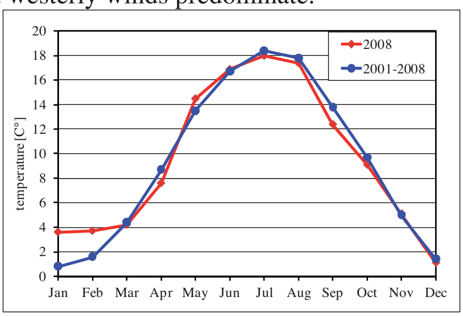

Figure VI.i - Average temperature in Germany

The temperature varies with the seasons and from region to region as shown in Figure VI.i and Table VI.i. The average annual temperature is 8.2°C and average annual total precipitation is 789 mm for the period from 1901 to 2007.

Regions	°C	mm
Germany	8.2	789
Bavaria	7.5	940
Hesse	8.2	793
Lower Saxony	8.6	746
North Rhine-Westphalia	9.0	845
Saxony	8.1	699
Schleswig-Holstein	8.3	788

Table VI.i - Average annual temperature and annual total precipitation across Germany from 1901 to 2007

Demographics

The territory of Germany covers 357,021km^2, consists of 349,223km^2 land and 7,798km^2 water. In 2007, the population of Germany was 82,217,837. It has the largest population among the member states of the European Union. However, the size of the German population has begun to decrease since 2003. This trend will continue, because of the further decrease of the birth - and increase of the emigration rate. In 2007, the total number of households was 39,722,000, 39% lived in a single-person household, 34% in double-person household and 27 % in a multi-person household. This is an increase of 13% since 1991.

Germany has many large cities, the most populous being Berlin, Cologne, Frankfurt a. M., Hamburg, Munich and Stuttgart. The density of population averages 230inhabitants/km^2. North Rhine -Westphalia, Bavaria and Baden-Württemberg are the populous states in Germany with over 10 million inhabitants each.

With the German reunification in 1990, many employees lost their jobs because of the relative inefficiency of the manufacturing companies in the former German Democratic Republic (GDR), the inadequate infrastructure and difficulties in resolving property ownership. These points initiated migration from the former east to western Germany.

This migration was a challenge for the Government and urban planning.

Carbon dioxide emissions

The total carbon dioxide (CO_2) emission for Germany is listed as 841 million tonnes in the year 2007 without the provision for land use, land use change and forestry. The CO_2 emission is divided into 80% fossil fuels, 12% industrial processes, 5% agriculture, 3% waste and others. Figure VI.ii shows the downward trend of CO_2 emissions.

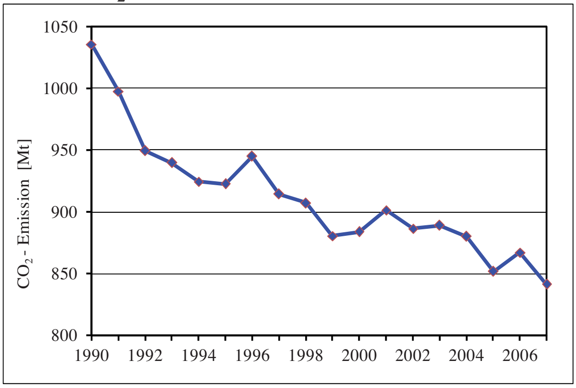

Figure VI.ii - CO_2 emission trend [Megatonnes] in Germany from 1990 to 2007

Energy in Germany

The central aims of the German Energy Policy are efficiency, security of supply and environmental compatibility. In 2008, the total annual primary energy consumption was 14,003 petajoule (PJ). Germany generates energy from a mixture of resources. The composition of primary energy resources is shown in Figure VI.iii.

As a country poor in natural resources, Germany is particularly dependent on energy imports. More than 70% of the total primary energy is supplied by imports (100% of the nuclear resources, 94% of the oil, 83% of the natural gas and 67% of the hard coal). The diverse mix of energy sources and energy suppliers from around the world is necessary to secure the energy supply. In addition to that, the German Government decided to phase out nuclear power. The last nuclear power plant (Emsland) is supposed to be closed by the year 2023. This will be compensated by reducing the energy demand through the increase of energy savings and efficiency as well as the use of renewable energy resources.

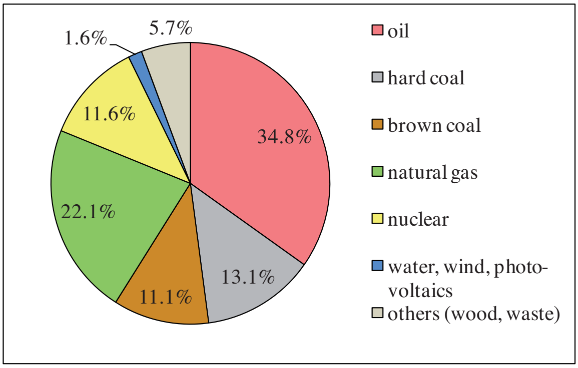

Figure VI.iii - Primary energy consumption in Germany by fuel type (2008)

Figure VI.iv shows the energy consumption by sector. According to figure VI.iv, there is a great potential to save energy in the sectors transport, industry and households. In the following, the paper will focus on the sectors household and construction.

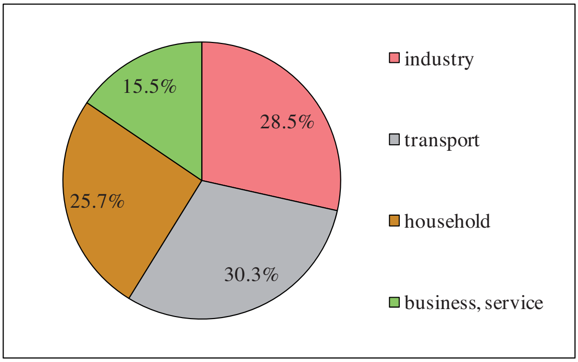

Figure VI.iv - Energy consumption in Germany by sector (2008)

Building regulations

The Federal Ministry of Transport, Building and Urban Development is responsible for the introduction of the Energy Saving Ordinance (EnEV).

The execution of the directive is regulated by the regional building regulations. In Bavaria the execution lies in the hand of the lower building supervisory board. The district heating inspector controls the compliance with the Energy Saving Ordinance.

EPBD implementation

The directive 2002/91/EC of the European Parliament and Council on energy efficiency of buildings ("Energy Performance of Buildings Directive", EPBD) was passed on 16th December 2002 and came into force on 4th January 2003. This Directive (EPBD) is considered a very important legislative component of energy efficiency activities of the European Union designed to meet the Kyoto Commitment. The directive is set to promote the improvement of energy performance of buildings with different requirements on buildings to be implemented by the Member States. Within these general principles and objectives, it is the individual responsibility of each Member State to choose measures that correspond best to its particular situation. 4th January 2006 was the official deadline for the 25 Member States to turn the directive into national law. For the requirement certifications and inspections the Member States had an additional grace period until January 2009 for the realization.

The implementation of the EPBD in Germany generally lies in the hand of the Federal Ministry of Transport, Building and Urban Development and the Federal Ministry of Economics and Technology.

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety is responsible for the area of boiler inspections.

The implementation of the EPBD was realised on the base of the Energy Saving Act ("Energieeinspargesetz"), which originally came into force in the year 1976 and defines the legal framework for requirements concerning:

- thermal insulation of buildings,
- the efficiency and energetic maintenance of appliance for heating, ventilation and hot water supply,
- billing of heating- and hot water cost are based on the individual consumption.

In Germany, most aspects of the EPBD have already been implemented by the Energy Saving Ordinance ("Energieeinsparverordnung", EnEV) 2002. Calculation methods for the energy performance have been based on the EnEV 2002. Energy performance certificates have been compulsory for new buildings and in case of certain major refurbishments, requirements for nearly all cases of modernization have been in place since 1984 without any limitations concerning the building size. Boilers need to be inspected in regular intervals since 1978 and need to be replaced if necessary. In terms of the directive (EPBD), compulsory certificates in the event of sale and a change of tenants in existing buildings had been missing. Furthermore, compulsory display of certificates in buildings for public services frequently visited by the public, as well as mandatory inspections of air conditioning units had not been part of the EnEV. The energy demand of air conditioning had not been taken into account in the calculation method.

All the missing aspects of the directive have been implemented by the Energy Saving Ordinance 2007. Since this ordinance did not change the level of requirements, the requirements are gradually enforced by the Energy Saving Ordinance in 2009. The requirements will be enforced in a first step by 30% and in 2012 again by an equal step. The new ordinance (EnEV 2009) was passed on 18th March 2009 and will most likely come into force by 1st October 2009.

These are the major changes/improvements of the Energy Saving Ordinance 2009:

- Increase of primary energetic requirements (energy performance) for new buildings and refurbishments of approximately 30%.
- Increase of energetic requirements for the buildings envelope in the case of major changes of the building of approximately 15%.
- Introduction of a reference building method for residential buildings. The determination of the maximum annual primary energy demand for the residential building is to be calculated on the base of a reference building of the same geometry, building floor space and alignment. The determination of the maximum annual primary energy demand depends no more on the surface-volume-ratio (A/V).
- Introduction of a new method of energy balance (DIN V 18599) for residential buildings which can be used as an alternative to the existing methods (DIN V 4108-6 and DIN V 4701-10).
- Successive shutdown of electrical thermal storage systems.
- Rules for the improvement of the execution of the ordinance.

Calculation method

For residential buildings, the calculation method for the primary energy demand based on the German pre-standards DIN V 4108-6 and DIN V 4701-10 remains in force. DIN 4108-6 is the German implementation of the EN 832, the DIN V 4701-10 defines the energetic assessment-standards for different heating-, ventilation- and hot water appliances including the climatic conditions in Germany and the use of the building. The pre-standard DIN V 18599 can be used to determine the primary energy demand for residential buildings, when the new ordinance (EnEV 2009) will come into force. This calculation method is an integrated assessment of the building envelope, built-in lighting installation and appliances for heating, ventilation, cooling and hot water supply. It consists of ten components with well-defined interfaces.

The primary energy demand for commercial buildings is to be calculated in accordance with DIN V 18599-1.

Energy performance requirements

The energy performance requirements are listed in the Energy Saving Ordinance (EnEV). There are separate requirements for residential, non-residential buildings and for the modernization of fabric elements (shown in table VI.ii). The requirements will be increased in a next step in the year 2012.

Fabric elements	max. U-Value [W/m²K]	
	EnEV 2007	EnEV 2009
outside walls (external walls with additional insulation)	0.45 (0.35)	0.24
windows (special glazing)	1.70 (2.00)	1.30 (2.00)
glass roofs	2.70	2.00
glazing (special glazing)	1.50 (1.6)	1.10 (1.6)
ceilings and walls to unheated space or earth	0.4	0.3

Table VI.ii - Requirements for existing buildings (in case of measures concerning the building structure)

Energy performance certificates

Energy certificates have been compulsory for new buildings as well as for defined cases of major refurbishments since 2002. The EnEV 2007 has only introduced a new layout to achieve a uniform design of the certificates for new and existing buildings.

The duty to provide energy certificates to potential buyers, renters and institutions for public services will be phased in, depending on the type and age of the building:

- July 2008 for residential buildings completed before the end of 1965,
- January 2009 for residential buildings built in 1966 and after,
- July 2009 for non-residential buildings.

There are no basic changes concerning the introduction of the EnEV 2009. The new certificate (shown in figure VI.v) is more transparent than the old one and includes references for renewable energy, calculation methods and heat insulation for the summer period.

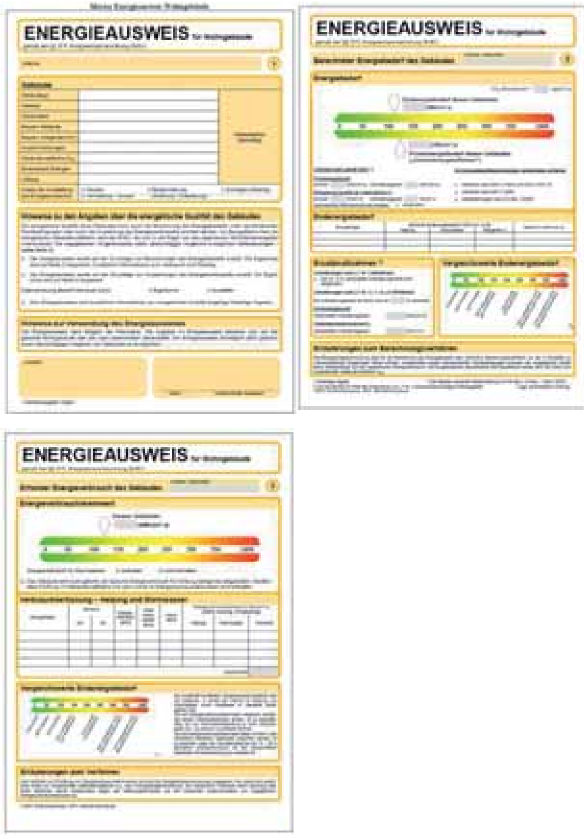

Figure VI.v - German energy performance certificate for residential buildings

Inspection of systems

The periodical inspections of boilers have been compulsory in Germany since 1978, namely to a much larger extent and with shorter intervals than foreseen in the EPBD. The requirements are generally included in an ordinance as part of the Emission-Act and energetic aspects by limiting the flue-gas losses. Germany has chosen “option b” of article 8 (EPBD). The inspections are done by a district heating inspector. Maintenance became mandatory for air-conditioners. This includes the checking of the nominal conditions of energetically relevant components by the maintenance technician. Air conditioning systems with more than 12kW have to be inspected by a special engineer every ten years. The engineer has to provide recommendations for cost-effective improvements to the owner. The requirements of article 9 (EPBD) are fulfilled by these measures.

Other initiatives

The Federal Government is currently introducing a programme to reduce CO_2 emissions from buildings. One of the Federal Government's housing and building policies is the energy conservation in the building sector.

A programme of €1.5 billion (starting April 2009) is an impulse for the construction industry and homeowners to tackle climate change. Apart from new buildings, the Federal Ministry of Transport, Building and Urban Development is clearly targeting the building stock in a systematic way.

Case study 1: Campus building, Munich

This residential home on the campus of the University of the Federal Armed Forces Munich was built in 1978. The energy performance and the CO_2 emissions of the building were analysed within the scope of a study.

The residential home for 108 students consists of three wings and a connecting part as shown in figure VI.vi. Each wing has 36 single flats with plumbing units, two shower rooms, two kitchens and a wide corridor. There are three offices and a large common room in the connecting part.

Figure VI.vi - Residential homes on campus (photo and ground plan)

The thermal shell exists of three different types of facades, a roof and a bottom plate. Table VI.iii displays the diverse thermal shells with the corresponding medium U-value.

Thermal shell	Construction	medium U-value [W/m²K]
facade type 1 external wall	12 cm masonry, 3 cm air layer, 5 cm mineral wool, 24 cm reinforced concrete	0.6
facade type 2 glass facade (figure 7 left)	double glazing	1.4
facade type 3 mixed facade (figure 7 right)	double glazed windows, fibrated concrete plates, board formwork	0.6
bottom plate	24 cm reinforced concrete with floor screed	0.8
purlin roof of wood	pantile, insulation, board formwork	0.5
windows	double glazing	1.7
doors	steel or wood	2.9

Table VI.iii - Thermal shells of the campus building with construction and medium U-value

Figure VI.vii - Facade (type 2 left and type 3 right) of the residential homes on campus

It can be seen, on the basis of table VI.iii, that the requirements of the Energy Saving Ordinance (shown in table VI.ii) are not fulfilled and that there is a clear difference between the required and the existing U-value. Thermal bridges und strong leakages were detected by a thermographic camera and the Blower Door Test. The thermographic photo in figure VI.viii shows the leakages and inadequate insulation.

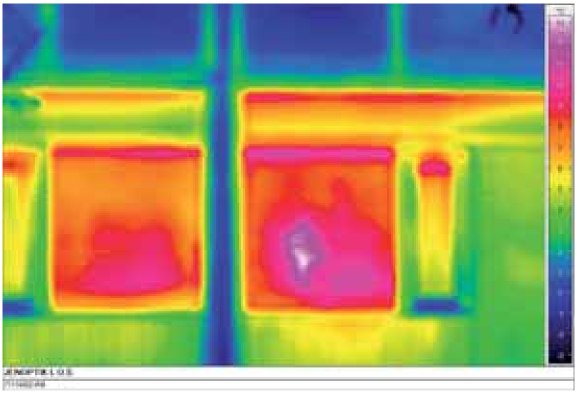

Figure VI.viii - Thermographic photo of facade type 3

The district heating system provides heating and hot water supply. The installed radiators are located at the external wall under the window.

This information about the existing residential home was the base for calculations and improvement measures. The total annual energy demand for heating and hot water preparation is 574.6 MWh per year. Corresponding to the heating transmitting surface of 3,486.5 m², the annual energy demand for heating and hot water preparation is 164.8 kWh/m² per year. The ventilation heat loss and transmission heat loss amount to 3,808 W/K and 3,911 W/K (surface-related value 0.83 W/m²K). The main reasons for the high energy demand are ventilation heat losses and transmission heat losses.

Fundamental reconstruction measures are necessary as a consequence of the high energy demand to meet the energetic requirements (EnEV).

Here are some possible improvements and reconstruction measures:

- facade 1: The external masonry has to be to substituted by a 18 cm sheep wool insulation (U= 0.17 W/m²K).
- facade 2 and windows: The installation of triple glazed panels/windows (U= 0.8 W/m²K) affords a great energy saving potential.
- facade 3: The mixed facade has to be changed by a prefabricated wooden frame facade with Vacuum Insulated Panels and polystyrene insulation (U= 0.2 W/m²K).
- bottom plate: The existing plate gets an additional construction in the form of phenolic expended plastic plates and 5 cm floor screed.
- purlin roof: Installation of a 22 cm cellulose insulation between the existing rafter (U= 0.2 W/m²K).
- doors: The doors have to be substituted by vacuum insulated doors (U= 0.6 W/m²K).

The energy-relevant values were determined for the existing building and after the reconstruction measures. The results of the calculations are listed in table VI.iv.

Energy relevant values	**Existing building**	**after recon-struction**	**savings**
annual energy demand for heating and hot water preparation	164.8 kWh/ m²a	48.8 kWh/ m²a	70%
transmission heat losses	0.83 W/m²K	0.30 W/m²K	64%
CO_2 demand	120.5 t/a	12.7 t/a	89%

Table VI.iv - Energy-relevant values of the existing building and after reconstruction

With the suggested measures it is possible to fulfil the energetic requirements, decrease the energy demand with the corresponding costs and reduce the CO_2 emissions. The greatest energy saving potential lies in the substitution of the doors the replacement of glazing with regard to the CO_2 emissions. Additional energy saving potential is provided by the substitution of the ventilation system and the installation of a photovoltaic or a solar heat system on the roof.

Case study 2: Refurbishment of a single-family home in Breitbrunn/ Bavaria

In 2005/2006, a duplex vacation home, which was built in 1970, was converted into a permanent residence for a family of 5 people. The main goals for the re-design and the refurbishment of the existing building were:

- Simplification of the floor plan
- Extension of the house
- Thermal improvement of the existing exterior walls, windows, roof and heating system

Figure VI.ix - Existing building in 2005

Figure VI.x: Refurbished building in 2006

The purpose of the existing building was to serve as a vacation home during the summer months. Due to the insufficient thermal performance, the building envelope had to be altered considerably to fulfil the requirements of the EnEV 2002 (Energy Savings Ordinance). Upon inspection of the walls, roof structure and the heating system it became clear, that a fundamental approach had to be taken to meet to legal requirements with regard to the thermal performance of the refurbished building.

Goal 1: Improvement of the building envelope

As the new function of the building was to serve as a permanent residence for a family of 5–6 people, the improvement of the building envelope was essential for increasing the comfort of the building while reducing the demand for fossil fuels.

While the existing structure (concrete slabs for floors and ceilings, brick for exterior walls) was intended to serve as thermal mass in the future, the main goal was to reduce thermal losses through additional insulation, reduced infiltration, improved glazing and window frames.T he individual measurements are described in table VI.v.

	before improvement	**after improvement**
Use of improved insulating glass for windows	2.80 W/m2K	1.25 W/m2K
10 cm therm. insul. added underneath floor slab basement	3.63 W/m2K	0.30 W/m2K
10 cm therm. insul. added underneath ground floor slab	3.63 W/m2K	0.20 W/m2K
4 cm therm. insul. added underneath ground floor slab facing the basement	2.10 W/m2K	0.62 W/m2K
12 cm therm. insul. added to outer walls (24 cm brick)	1.33 W/m2K	0.22 W/m2K
Roof main building w. 20 cm therm. insul.		0.22 W/m2K
Roof winter-garden w. 20 cm therm. insul.		0.22 W/m2K

Table VI.v - Thermal properties of the building envelope before and after the refurbishment

Goal 2: Improvement of the heating system

The use of a highly effective oil or gas burner is a standard solution for most of the private homes throughout Germany, as modern condensing boilers have an efficiency of 104%, due to the extraction of the heat of the fumes through a heat exchanger. This option was rejected due to the high CO_2 emissions.

To reduce the amount of CO_2 emissions, a heat pump system was considered. As a general rule, the total energy balance of a heat-pump system consists of 75% of environmental energy (air/water/soil) and 25% of electricity for the generation of hot water.

The environmental energy is gained through pipes/wells, driven into the ground to a depth of 50–75 m. These long double pipes, which serve as heat exchangers, are considered to be a state-of-the-art and proven solution. However, the client was concerned about the high investment costs. Furthermore, the demand for electrical energy to run the heat-pump would have been considerably high and would have led to notable CO_2 emissions.

Therefore a careful analysis of a pellet heating system was chosen, since wood is a CO_2 neutral fuel, which is widely available in Bavaria. The production of pellets is based on high standards (DIN 51731). The projected volume of the pellets was approx. 10–12 m^3 per year. With pellet heating systems, only 1.0–1.5 % of the contained energy is needed for transport and only 0.5–1.0 % for transport.

The management of the heating system is done automatically and the ash has to be removed every 6–8 weeks, which was not an issue with the client. A further aspect was the reduced costs for pellets in comparison to oil.

Costs / CO2 emissions	Oil-fired	Pellets	Heat Pump
Investment costs in €	19,500	24,500	43,500
Running costs in €/year	2,700	2,100	1,200
CO2 emissions kg/year	11,800	0	6,900

Table VI.vi - Cost-benefit and carbon analysis

Due to the general willingness of the client to find the best solution with regard to the environmental qualities of his new building and his willingness to invest slightly more and to take personal care of his heating system, it was decided to build a pellet-heating system.

Summary

From the beginning of the design in 2005 and the construction in 2006 onwards, the improvement of the quality and comfort, the reduction of CO_2 emissions and the improvement of the aesthetics of the buildings were regarded as equally important. The client moved into the house in late 2006 and has confirmed that all the requirements were met by the house he received, including the projected energy performance. As planned, the new building does not only meet the requirements of the ENEV 2002, but also combines a good building envelope with low U-values with the options to use passive solar gains for the balancing of the thermal performance. Due to the decision to generate heat by using a carbon-neutral fuel, the CO_2 emissions for the heating and producing of hot water are zero.

Planning legislation

In 2007, the CO_2 emission in Germany was 841 million tonnes. The decreasing trend of CO_2 emission is diagrammed in figure VI.ii.

The regulation for CO_2 emissions for buildings in Germany is the Energy Saving Ordinance (EnEV). Approximately 17.3 million residential and 1.5 million non-residential buildings produce 20% of the total CO_2 emissions. 73% of these buildings were built before 1978 without any thermal insulation regulation. This offers an important energy and CO_2 saving potential. The costs for heating and hot water are a large part of residential operating costs (circa €0.86 per m^2 of floor space). In a 60 m^2 flat, this equals €52 per month. In many cases, thermal insulation and modernized heating systems can reduce the energy and CO_2 demand by 30% to 50%. For this reason, the Federal Government's supports CO_2 reducing measures by investments in the building stock. Energy conservation in the building sector is a main aim of the Federal Government. The reasons are:

- Measures to improve the energy efficiency, reduce individual energy consumption, and thus service charges, while significantly improving the quality of housing.
- These improvements decrease CO_2 emissions and thus help to tackle climate change.

The Federal Government's programme provides direct grants and loans for owners of freehold apartments, one- and two-family-houses. That way, renters and owners can enjoy a better housing environment and lower energy costs, while the building emits less CO_2 into the environment.

Another action to decrease energy demand and CO_2 emission is the contracting programme for Federal Government Properties. In 2000, the Federal Government decided to reduce CO_2 emissions for government properties by 2010 by 30% when compared to the value of emissions in 1990. In order to meet this voluntary commitment with innovative solutions but without additional budgetary appropriations, the pilot project "Energy Contracting for Federal Government Properties" was called in to being in 2002. This means that contracting involves a formal service agreement between the building owner and a specialized energy service provider (contractor). The contractor plans, finances and implements measures to conserve energy or to improve the energy supply. The project aims to improve the energy efficiency of as many federal government properties as possible, to use the existing energy conservation potential, to reduce carbon emissions and to cut costs. The execution and control of the project lies in the hand of the German Energy Agency (dena). The Federal Ministry of Transport, Building and Urban Development is responsible for the financial and technical support.

The implementation of the 40 energy contracting projects currently in operation or specifically planned will result in the following potential savings:

- energy cost saving guarantee of approximately €3.4 million per year,
- immediate reduction of the burden on the federal budget of approximately €0.63 million per year,
- reduction of CO_2 emissions of approximately 18,000 tonnes per year.

City case study: Munich

Munich is the capital, and the largest city within the Federal State of Bavaria. Located in the south of Germany, Munich has 1.3 million inhabitants (2007) and is the 3rd largest settlement in Germany.

Munich is a relatively flat city, surrounded by a rural landscape with forests, modest green hills and the Bavarian Alps to the south. Due to its geographical location and proximity to Austria and Italy, Munich became an important support point for the trade between Bavaria and Germany with its southern neighbouring countries after it was founded in 1158.

Location	**Latitude:**	48.13° N
	Longitude	11.70° W
	Size	310 km^2
Climate	**Temperature**	-4 °C - 22 °C
	Av. Rainfall	855 mm (33.5in).
Population	**1991**	1,229,052
	2001	1,227,958
	2007	1,356,000
	Density	4370 inhabitants per km^2
	Households (2007)	741,674
Energy use per capita		4.23 toe/capita (2006)[1]

Table VI.vii - Statistics about Munich

Surrounded by a highly attractive landscape with large lakes, mountains and lush vegetation, Munich has a rich cultural history, which annually attracts approximately 5 million guests (2008). Two of the most well-regarded German universities are located in Munich (Ludwig-Maximilians-Universität and Technische Universität München). Roughly 10% of Bavaria's population (12.5 million in 2007) live in Munich, which is also one of the oldest multi-cultural communities in Germany.

Buildings

Traditionally, housing in Munich comprises of mid-density, 4-5 storey condominium buildings which were built around block-type settlements in the inner part of the city in the late 19th and early 20th century. With the tremendous growth occurring in the 50s, 60s and 70s of the last century, more open structures with 5–10 storey condominium buildings were added. Along the edges of the city, sub-urban settlements were established with a mix of single family homes and sub-urban high-density developments, such as the condominium towers and slabs. After a fast increase in population until 1972, the year the Olympic Games were held in Munich, the population has grown from 1.338 million in 1972 at a moderate rate to 1.436 million in 2005.

Transport

In preparation for the Olympic Games, the infrastructure of the transport system was changed considerably. Major ring-roads, such as the "Mittlerer Ring" allowed for a connection of the incoming freeways along the periphery of the inner city. In addition to the international, national and regional train system, two additional train systems were established. These two systems, the "S-Bahn" (high-speed regional train system) and the "U-Bahn" (underground train system) complement the local tram and bus system. The Olympics helped to support the establishment of one of the best public transport systems in Germany.

In addition to connecting Munich with its surrounding communities, the public transport system allowed for banning the car from the inner part of the city. In 1972, one of the first and for many years the largest pedestrian zones had been established which has proven to be one of the most attractive (and expensive) car-free areas in Germany.

Environmental footprint

With carbon emissions of 9.8 metric tons of CO_2/capita in 2004, Germany was ranking 38 behind the leading country Quatar (69.2 to CO_2/capita) or the USA, ranking 10 (20.4 to CO_2/capita).[2]

Specific data for the carbon footprint of Munich is not available. However, the city has committed itself to reduce its carbon emissions by 50% until 2010 compared to 1987. As almost 50% of the energy used

[1] IEA Energy Statistics—Energy Indicators for Germany. See: www.iea.org/Textbase/stats/indicators.asp?COUNTRY_CODE=DE, retrieved on June, 12th, 2009 (toe = tons of oil equivalent)

[2] http://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions_per_capita#Carbon_dioxide_emissions_per_capita, retrieved on June 12th, 2009

in the city is attributed to district heating and electricity consumption, the public utility company "SWM" of Munich is likely to reach this goal by supporting energy conservation measures in the building sector as well as reducing individual car use through enhancing the use of public transport[3], car-sharing programmes and the enhanced use of bicycles through the creation of a consistent bike-path network.

Looking forward

Munich has committed itself to developing into an eco-friendly city based on energy efficiency, and integrated transport systems. Alternative forms of community planning, including low-energy buildings, are supported by the city and are coupled with low-carbon transport concepts, such as integrated public transport systems, bike-friendly bike-path networks and car-sharing concepts, such as the "Messestadt Riem"[4] and the "Ackermannbogen."[5]

The reputation of Munich being one of the most "livable" cities in Germany is supported not only by its numerous parks, lakes and cultural assets, but also by its very dense public transport system, which allows access to almost any point within its city limits without the need for a car.

National conclusions

Considering the recent findings about climate change, Germany is on the right path to reach the climate aims of the Kyoto Protocol and their own high standard. Germany has committed itself to a reduction of 40% by the year 2020 compared to 1990 levels.

The successful implementation of the German Saving Ordinance (EnEV), Federal Government projects and financial support are necessary to conserve energy and tackle climate change.

Investments in the building stock make sense to reduce CO_2. The building of a new residence produces more CO_2 than the reconstruction with a corresponding insulation. Additional energy saving potential provides the use of renewable energy forms in the building sector. Solar and geothermal energy can be used to generate electricity and hot water.

According to the energy and CO_2 saving potential of the building sector, further efforts are necessary to save energy and protect our environment. With the pilot project "Energy Contracting for Federal Government Properties", the German Government hopes to identify approaches, which can serve as model for other authorities. Apart from the law and the regulations, the environmental awareness of each person is very important for our environment and society.

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[4] http://www.muenchen.de/cms/prod1/mde/_de/rubriken/Rathaus/75_plan/05_bebplanung/pdf/oekobaustein_mr_1.pdf, retrieved on June 12th, 2009

[5] http://www.stmi.bayern.de/imperia/md/content/stmi/bauen/themen/gebaeude_energie/beispielhaftebauten/mehrfamilienhaeuser/1obb_muenchen_ackermannbogen.pdf, retrieved on June 12th, 2009

VII Greece

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National context

Greece is located in the southern part of the European continent and belongs to the Balkan Peninsula. The surface area of Greece is 130,000 km^2 of which 20% is distributed to its 3,000 islands, whereas, two thirds of the Greek territory is mountainous. Greece has the longest coastline in Europe with a total length exceeding 15,000km of which 5% belongs to areas of unique ecological value. Athens is the capital. As far as the carbon emissions are concerned, the Greek government agreed to the UN Framework Convention in 1994, and became a signatory to the Kyoto Protocol, ratifying the protocol in 2002 with Law 3017/2002.Under the EU agreement from 1998, Greece has to restrict the increase of GHG emissions to no more than 25% from base year levels.

Climate

Greece has a Mediterranean climate with mild winters and dry summers. However, the climate in Greece varies from region to region. For example, the islands have smaller differences of temperature during the day than the mainland. Western Greece has more rain than the eastern part. Northern Greece has a colder climate than the rest of the country. The Ionian islands and southern Crete have the best climates with very small differences between winter and summer temperatures. The Aegean islands have less rainfall and they experience strong winds in summertime.

Region	1990-2000	2001	Oct 2008
Athens	17,9	19,5	19,8
Thessaloniki	16,2	16,9	17,2
Ioannina	14,1	14,9	14,7
Rodos	19,4	20,2	21,6
Kozani	13,3	14,2	14,2
Naxos	18,4	18,9	19,7
Herakleio	18,8	19,5	20,6

Table VII.i - Average temperature (in °C) for different regions across Greece (www.hnms.gr)

Demographics

The national population reaches 11 million with a density of 84 inhabitants/km^2 – one of the lowest densities in Europe. According to the National Statistical Service (NSSG, 2008) the population in 2006 came up to 11,148,533. One third of Greek population concentrates along the coastline.

According to the 2001 census 72.8% of the population is urban, while 27.2% is rural. During the last 15 years the average annual population increase is approximately 0.5% and decreases steadily reaching the EU average. Based on the aforementioned the population is aging as 16% is over 65 years old. This trend goes along with the fact that the life expectancy is approximately 80 years old. It is worth mentioning that over one million of foreign immigrants entered Greece during the 1990s consisting today 15% of the total working force. Approximately 370,000 foreign immigrants were legitimised in 1998 and 2001.

Economic features

In 2008, the GDP came up to 245 billion Euros while the per capita GDP reached 22,200Euros. The structure of the Greek economy presents significant increase in the service sector, contributing with 68.5% to the Gross Production Value (GPV). Tourism plays an important role as Greece is ranked among the 20 important tourism destinations globally. The contribution of the manufacturing sector is limited (23.5%), while industrial activity concentrates in traditional sectors dominated by a large number of small and medium sized enterprises making the sector vulnerable to external pressures from international competition.

Energy in Greece

Greece is a net energy importer, since its total energy consumption exceeds its production by a significant margin. The country's import dependency on energy sources reached 72.7% in 2004, including bunkers (ZEP, 2007). Greece accounts for about 0.3% of the world's total annual energy consumption. In 2004 the country's gross inland energy consumption was 30.6 Mtoe, derived mainly from oil (17.5 Mtoe) and lignite (9.1 Mtoe). Natural gas share was 2.2 Mtoe and the Renewable Energy Sources (RES) was 1.6 Mtoe. In 2004 the 20.2 Mtoe of total final energy consumption were dominated by oil (13.9 Mtoe), followed by electricity (4.3 Mtoe) and RES (1 Mtoe, including large hydro plants). By that year, natural gas exploitation was still limited, although growing rapidly. Regarding energy consumption in various sectors, transport is the largest final energy consumer (8 Mtoe in 2004), followed by the residential sector (5.4 Mtoe) and the industry (4 Mtoe). It is worth mentioning the large share of road transport and the limited development of the railways.

Carbon dioxide emissions

In the recently published report on CO_2 emissions based on regional assessments, the total CO_2 emissions for Greece, in 2003, are listed as 138 Mt of CO_2 equivalent (IEA, 2006). 55% of total national emissions are fossil-fuel related and 79% are from the energy sector (Figure VII.iii). It is important to notice that they have risen by slightly more than 25% over the past decade. In 2004 Greece's CO_2 emissions from energy production came up to 94 Mt (excluding maritime bunkers), the CO_2 emissions per capita 8.5 t CO_2/ca. The latter is close to the EU-25 average figures (8.5 t CO_2/ca), the emissions intensity is too high compared to other European countries (2.21 t CO_2/toe EU-25 average). This is mainly attributed to the power production structure as well as to the small RES penetration.

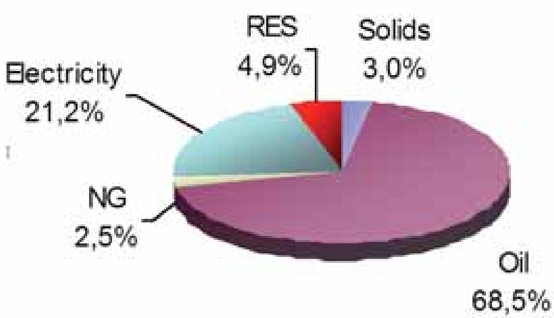


Figure VII.i - Energy consumption in Greece by fuel type (2004)

Building regulations

The main Greek legislative structures involved in the generation and application of regulations related to the urban built environment are the Ministry of Development, the Ministry for the Environment, Physical Planning and Public Works, local offices of urban planning (stemming from and reporting to the ministry for the Environment, Physical Planning and Public Works) and the Technical Chamber of Greece.

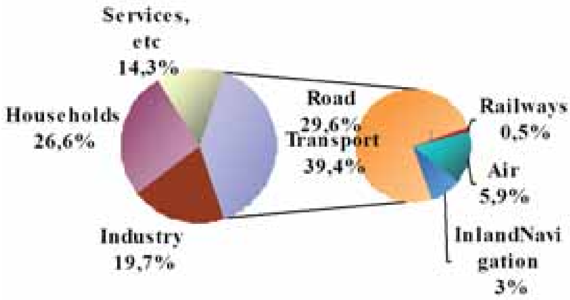


Figure VII.ii - Energy consumption in Greece by sector (2004)

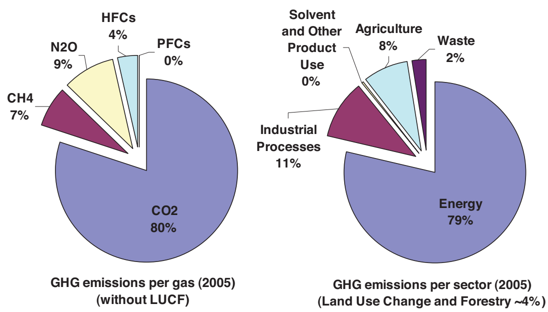


Figure VII.iii - GHG emissions for Greece (2005)

The ministry of Development and the ministry for the Environment, Physical Planning and Public Works are jointly responsible for implementing the EPBD and introducing relevant regulations. Compliance to these would be ensured through the local offices of urban planning through which building permits are actually issued. Incentives targeting the use of renewable energy technologies in the urban environment are introduced through the Ministry of Development. In both cases, the advice of the Technical Chamber is sought, although this is not always the case.

The general framework through which legislation is passed would be the announcement of a draft proposal by the ministry, occasionally after discussions with other relevant authorities (i.e. Technical Chamber) and/or the public. The draft would then be submitted to a parliamentary vote before becoming a law of the state. Legislations usually specify the body responsible for determining specific points within them, a procedure that might take longer than the actual legislation. This would usually be either the President (Presidential Decree) or the Ministerial Cabinet (Cabinet Decisions). Ministries appoint official committees to study and propose regulations, often accompanied by the advisory role of the Technical Chamber.

EPBD Implementation

Most of the previous legislation is outdated and being revised i.e. the Thermal Insulation Regulation (1979) and the latest modification of the General Construction Regulation (2000). Specific EPBD legislation is still being formed, mainly through the recent law for the "reduction of energy consumption of buildings and other measures" (3661/08). However, specific details and actions are still at the stage of public review and are expected to be finalised in Spring 2009.

The procedure currently being proposed is based on the ISO EN 13790:2008 methodology for calculation of building energy performance and compliance with the EPBD, depending on the type of building (domestic/commercial) and the systems installed (heating, cooling, hot water etc.). Details of the methodology and the format of energy performance certificates (through standard prEN 15217:2006), as well as the structure and training requirements for building energy auditors are also included but are not described here since they are not definitive at the time of writing.

Other initiatives

Financial and other initiatives include the financial Initiative EPAN 2.1 2000-2006 (Ministry of Development) which financed 40% of the initial costs, of projects from €40K to €40M, for the introduction of CHP and RES across the country and the Law 3299/2004 (Incentives for Private Investment for Economic Development and Regional Convergence), which finances 40-55% of the total investment for introduction of environmentally friendly technologies (combined heat and power, renewable energy sources, heat recovery, biofuels, biomass etc) in the production process. The 2nd National Programme for Climate Change was developed and adopted in 2003 (Ministerial Council Act 5/27-2-2003) with an aim to establish a set of policies and measures to reduce greenhouse gas emissions so Greece may fulfil its national obligations under the Kyoto Protocol during the first commitment period (2008-2012). In the National Program there are proposals for a series of actions aiming at the proper use of energy in the residential and services sector including improvements in the energy performance of existing buildings with changes in the shell, upgrades to the HVAC system, promotion of more efficient electric appliances, changes in lighting, further exploitation of natural gas etc., further promotion of renewable energy sources, primarily the use of solar systems, photovoltaic and biomass (district heating). The capacity for greenhouse gas emissions reduction in the residential and services sector as calculated in the 2nd National Program is projected to be 2.3 Mt CO_2 eq for the year 2010. One of the latest legislative measures is Law 3468/2006 (Electricity Production from Renewable Energy Sources and high Efficiency Combined Heat and Power). Through this legislative measure, Greek law complies with the 2001/77/EC Directive and the structures and processes for electricity production from RES are clearly stated. Details regarding installation, connection to the grid and the pricing policies for the produced electricity are stated. In combination with the financial incentives laid out in Law 3299/2004 there has been increased activity and interest.

Case study 1: Buildings connected to the Kozani district heating system

About 60% of electricity in Greece is produced from thermal power stations (lignite) in Western Macedonia. Four major district heating systems are connected to thermal power plants in the region: Kozani (81.4 MWth), Ptolemaida (69.8 MWth), Amyntaio (34.9 MWth), Megalopoli (20 MWth) (Figure VII.iv).

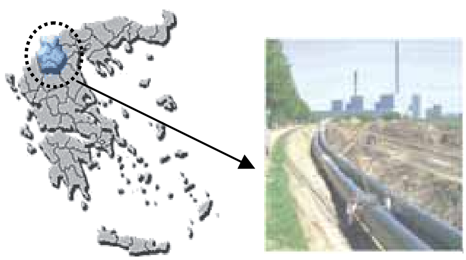


Figure VII.iv - District heating system in Western Macedonia, Greece

The city of Kozani has a population of over 50,000 and is at an elevation of 625m. During the winter, the mean minimum temperature is -10°C but summer cooling requirements are minimal. The Kozani district heating system began operation in 1993 and gets most of its energy from co-generated heat from lignite fueled power plant Ag. Dimitrios (1595 MWe). Today, there are over 3,000 buildings connected (95% of Kozani's building stock ~1.6M m^2) with 20 kTOE saved per year. The purpose of the present study is to evaluate the characteristics and heating operation of a significant sample of residential buildings, estimate the major greenhouse gas emission level savings and evaluate the effect of a selection of building envelope improvements with regard to further savings. Detailed data of 67 buildings in Kozani was obtained from district heating bills (1999-2003), urban planning offices and a supplemental questionnaire. All buildings studied were residential, self managed, and ranged from 1-7 floor levels giving 60-5000 m^3 per building. Regulations on envelope thermal characteristics are still based on the 1979 thermal insulation law, which requires a mean U-value below 0.62 W/m^2K. Current heating installations allow for return water at 40-60°C and most buildings include thermal solar installations for domestic hot water use. A final sample of 20 buildings was studied, with four buildings (Figure VII.v) being singled out for testing envelope improvements such as double glazing and external insulation.

Figure VII.v: Four buildings for envelope improvement studies

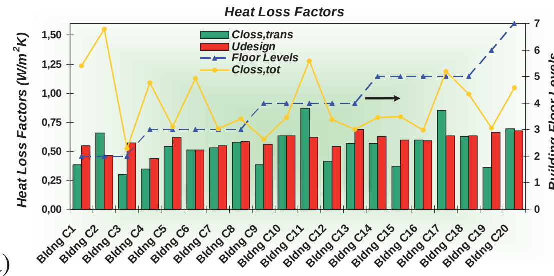
Total energy consumption ($Q_{tot,meas}$) was analysed to distinguish building envelope transmission losses ($Q_{trans,calc}$) and these were compared to the expected design values ($Q_{trans,design}$) using the degree day (DD) method. Ventilation and infiltration loads (Q_{inf}) were evaluated from questionnaire data, on-site observation and the DIN 4701 infiltration method. Internal heat gain (Q_{gain}) and hot water usage ($Q_{h.w.}$) (also provided from district heating system) were evaluated from questionnaire data. Floor area normalised values were calculated but also, as an indicator of building envelope performance (area: F), overall building "heat loss factors" ($C_{loss,tot}$, $C_{loss,trans}$) were defined:

$$C_{loss,tot} = Q_{tot} \Big/ F \cdot DD \quad , \quad C_{loss,trans} = \left(Q_{tot} - Q_{inf} - Q_{gain} - Q_{h.w.}\right) \Big/ F \cdot DD$$

Comparison of measured and design value energy losses, transmission and total, is presented in Figure VII.vi in the form of heat loss factors and energy consumption. Most U values comply with the legal limit and the energy losses are generally lower than the national mean.

Calculations of gas emission (e) savings were performed assuming replacement of conventional sources (considering burning efficiency of oil or natural gas, η) and excluding energy source production and transport costs. The CO_2 equivalent greenhouse warming potential (GWP) of CH_4 and N_2O was also included (Table VII.ii):

$$e = \left(e_{CO_2} GWP_{CO_2} + e_{CH_4} GWP_{CH_4} + e_{N_2O} GWP_{N_2O}\right) \frac{1}{\eta}$$



a) b)

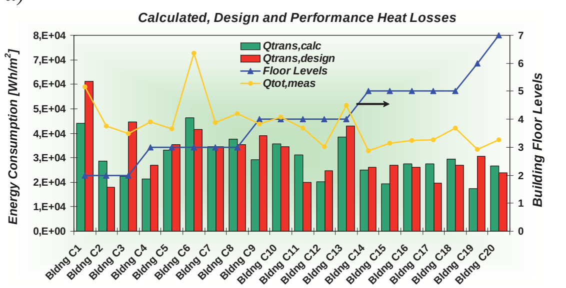


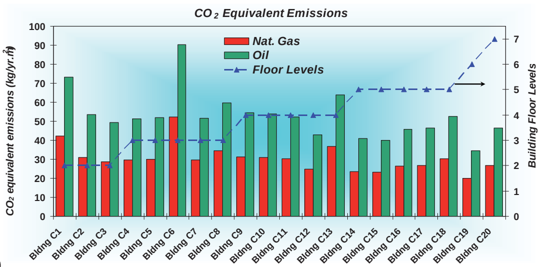
Figure VII.vi - a) Heat loss factors and b) Heating Energy Consumption, for the test sample

	e_{CO2} [kg/GJ]	GWP CO_2	e_{CH4} [kg/GJ]	GWP CH_4	e_{N2O} [kg/GJ]	GWP N_2O	H (%)
Nat. Gas	56,1	1	0,003	21	0,001	310	85
Oil	74,1	1	0,002	21	0,002	310	65

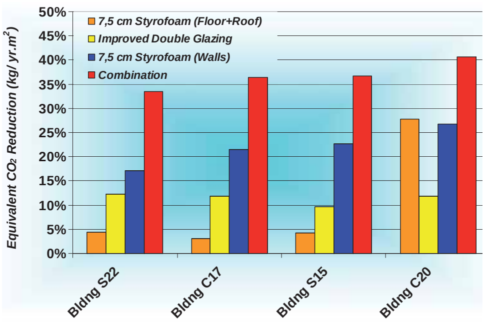
Table VII.ii - Greenhouse warming potential and fuel burning efficiency for Natural Gas and Oil (Source: GHG Emission Reduction Analysis Model. Retscreen: www.retscreen.net)

Potential percentile reduction in CO_2 emission was estimated by detailed calculation of the effect of retrofitted insulation (Styrofoam on walls, roof + floor) and/or improved double glazing but emissions from the distribution and production system were not included. U values were recalculated and reductions in energy consumption and relevant CO_2 emissions were evaluated (Figure VII.vii).

Although the Kozani district heating system is connected to a power plant burning low quality lignite fuel, the positive impact of the system was shown through calculation of emission savings in comparison to standard space heating methods using fuel or natural gas burners. The building sample that was studied was found to generally comply with the weak thermal transmission loss restriction and further emission savings were shown to be possible through simple retrofitting measures targeting the building envelope.



a)



b)

Figure VII.vii - a) Equivalent CO_2 emissions saved through the district heating system and b) potential emission reduction for envelope improvement measures

Case study 2: Sol Energy Hellas Pilot Building

This particularly innovative project is a pilot implementation of the solutions for integrated energy design of autonomous buildings that have been favored during a subsidized research program of the General Secretariat for Research and Technology (G.S.R.T.) of the Greek Ministry of Development. Sol Energy Hellas was the project co-ordinator and other participants were: National Center for Scientific Research "DEMOKRITOS", Aristotle University of Thessaloniki, Dept. Mech. Eng., Process Equipment Design Laboratory and the National Technical University of Athens, Dept. Chem. Eng., Laboratory of Inorganic and Analytical Chemistry.

The building site and construction was chosen with the intention of becoming the main offices of Sol Energy Hellas. The general form and architecture are typical it is fully integrated into a relatively dense urban surrounding in the area of Palaio Faliro in Athens, Greece. The following technologies were developed and integrated: *Hot water generation by high-efficiency flat-plate solar collectors for heating and air-conditioning:* 30 solar collectors have been installed on the roof of the building with a total area of 84.6 m^2. *Seasonal thermal storage in non-metallic tanks. Solar cooling (absorption technology). Solar-assisted desiccant cooling. Shallow geothermal energy - geothermal heat pumps:* a water-cooled heat pump is connected with two independent geothermal-type circuits: a closed loop circuit of a geothermal exchanger, consisting of five parallel branches and an open loop circuit supplied by untreated underground waters pumped through wells and an appropriate flat plate heat exchanger. *Passive energy design:* design and construction solutions have been adopted in the building to reduce energy loads according to bioclimatic architecture principles, involving interventions to the building shell. *Windows:* double-glazed panels of low emittance and high reflectance have been used in combination with thermal break aluminum frames to avoid thermal bridge effect. *Lighting:* high-efficiency fluorescent lamps and low heat emission lighting fixtures have been selected to minimize electricity consumption. *External thermal insulation:* an outer shell of thermal insulation has been installed leaving a 2cm gap between the outer shell and the bearing structure of the building. *In-wall and in-floor heating and cooling. "Pre-air-conditioning" fresh air through double-element central air-conditioning units. Photovoltaic panels:* on the eastern facade of the building 44 P/V amorphous silicate panels have been installed for a total of 4.4 kW_e.

a)

b)

c)

Figure VII.viii - Outer views of a) the terrace with flat plate solar collectors and b), c) the building and its surroundings

Controlling the building subsystems and recording the corresponding data is performed through special sensors and instruments, which have been dispersed to appropriate locations of the shell and along electromechanical systems. Data are stored and processed by a central processing unit equipped with specialized software for regulating the systems depending on ambient and indoor conditions (comfort conditions). Management of thermal storage and individual systems aims at minimizing energy consumptions while preserving excellent comfort conditions inside the building. Finally, a weather station has been installed on the roof in order to accurately record ambient conditions.

With regard to the economic viability of such a pilot building the energy consumption for heating and cooling were calculated and compared to the existing measured data from the 6 month operation of the building.

Figure VII.ix - Panoramic view of the main installations in the basement of the building

A basic financial analysis has shown that a payback time of 8½ years is expected for the cost of extra installations, when compared to a conventional building. Depending on availability of subsidy or third party investment, payback time will reduce linearly to 4½ years for a subsidy of 50%.

During the first few months of operation the building has proven to have met the performance criterion of heating-cooling energy autonomy. No external power source has been used for this purpose and the indoor comfort levels are at an excellent level. Full assessment of the building's operation will be possible after it completes a full annual cycle of operation.

Environmental impact of the use of energy saving technologies in the pilot building can be translated into over 350 tonnes of annual equivalent CO_2 emissions savings. This can be converted into cost savings if one considers a cost of €19,00/tn CO_2 based on the emission allowance auctioning costs of €10,00-28,00/tn CO_2. The annual savings come to €6,900,00/ann. or €75,000,00 in present worth after 15 years. The breakdown of the environmental impact in CO_2 equivalent terms is shown in Figure VII.x.

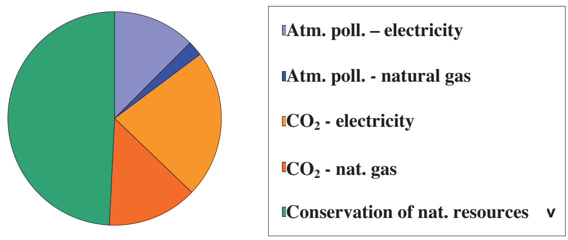


Figure VII.x - CO_2 equivalent savings breakdown from the technologies applied in the present building

The case has proven that the integration of these technologies is possible at an urban scale and that economic viability can be attained with careful mechanical and architectural design. The main benefits from the realization of the project result from the systematic treatment of all fundamental problems related to the construction of this type of installations, integrated design of building and subsystems and the evaluation of technically possible solutions, demonstration of their feasibility and return on investment through the pilot-demonstrative installation. Immediate expected benefits are the increasing competitiveness of products utilized, enhancing business activities of the Greek solar energy industry, and additional reduction in energy use and CO_2 emissions. Further details on the building are available at (Sol Energy Hellas, Promitheas Pirforos, www.promitheaspirforos.gr).

Case study 3: Athens

Athens has a reputation for being polluted and often jammed by traffic during rush hours. The promise of the Greek government when they bid for the Games (in 1997) was that, by 2004, air pollution in Athens would be reduced by an average 35%. This would be achieved by a series of measures including more and better public transport, new means of transport (such as metro, tram and suburban rail), better fuel quality, and more efficient vehicles. Although the levels of some pollutants (such as sulphur dioxide, lead, and carbon monoxide) have shown a decreasing trend in the 90's, Athens still has serious problems with regard to the levels of ozone, volatile organic compounds — VOCs (such as the carcinogenic benzene), and particulates (which are generated mainly by diesel vehicles). Ozone, benzene and particulate (PM10) levels are still very high, despite the improvement of public transport infrastructure, mainly due to the high rate of increase in cars in Athens, the lack of adequate emissions controls, and the delays in introducing alternative non-fossil fuels (such as biofuels for example).

There is some good news regarding public transport. A new metro line has been built, gas-fuelled buses have been introduced (Athens has now the largest gas-fuelled bus fleet in Europe), and some €3 billion have been spent in public transport (extension of metro, introduction of tramway and suburban rail, modernization of bus and trolley fleets, tripling of bus-only lanes). It was estimated that 50% of people will be using the public transportation system by the end of 2006. This is probably the most impressive achievement. On the negative side are the delays in the construction of adequate parking lots (particularly near the metro stations to facilitate park-and-ride) and the overwhelming increase in the number of cars, which presently dominate the city. A particular problem is the high number of diesel-fuelled taxis (14,000), which account for some 20% of all traffic, thus contributing a remarkable share to the emissions of particulates to the atmosphere. Although the government has recently announced some incentives for the renovation of the taxi fleet, no radical measures have been proposed, and there is no availability of biofuels in the country as yet. Biodiesel could have served the taxi and bus fleets, contributing to a cleaner atmosphere. The irony is that in just a few months (as of 2005), the EU requires that biofuels make up 2% of all transport fuels. As of the beginning of 2006 the government has announced plans for the conversion of city buses to use natural gas. This move will help in reducing emissions of CO_2 and $NO_x$and SO_x. Major public works promote the quality of social life and the environment in a community. If they are well planned then there are a lot of benefits. Environmentally speaking, the metro usage causes less carbon emissions because people don't use their private cars. Also the alternative energy resources that are used in Solar Village prevent the further consumption of conventional fuels because an important percent of energy needs is covered by renewable resources. Finally the materials that have been used in the construction of the Olympic Village constrain the energy needs for heating due to better energy behaviour. This reduction of consumption of conventional fuels has as result less air emissions and more effective energy usage. Description of these three case studies, with specific details on their impact on lessening the carbon emissions follow.

Case Study 3.1: Metro of Athens

Objective

The objective of Attiko Metro programme was to minimise air and noise pollution and any other pollution related to the use of personal vehicles and to promote sustainable transportation. The greater Athens area would benefit from applying the sustainable transportation concept through encouraging and promoting the use of public transportation means. By comparing the atmospheric emissions in the 6-year periods before the implementation of the programme, a significant improvement in the air quality has taken place, ranging from 13.5% for O_3 to 47.3% for SO_2 (Table VII.iii). This reduction is far more significant than it appears, considering the fact that the vehicle fleet has increased by 68% in the years 1993-2000, and that fuel consumption has increased by 36% for petrol in the same period.

Pollutant	Av. Conc. 1987-1993	Av. Conc. 1994-2000	Reduction %
CO (mg/m3)	6.8	5.2	-23.5
NOx (µg/m3)	187	138	-26.2
NO2 (µg/m3)	114	96	-15.8
SO2 (µg/m3)	74	39	-47.3
Smoke (µg/m3)	82	69	-15.9
O3 (µg/m3)	74	64	-13.5

Table VII.iii - Emissions from transportation in Athens before the usage of Metro (www.minenv.gr)

The Metro started operating in the year 2002 it consists of two lines. The whole project is divided into three phases:

The Stations of the Base Project:

- *MONASTIRAKI-ETHNIKI AMYNA (7 Km) &*
- *DAFNI - SEPOLIA (10 Km)*
- The Stations of the First Generation:
- *ETHNIKI AMYNA - DOYK. PLAKENTIAS (5 Km), DAFNI-HELLINIKO (6Km), MONASTIRAKI – EGALEO (4 Km) &*
- *SEPOLIA-ANTHOUPOLI (3 Km)*

The Stations of the Second Generation:

- *PANORMOU-MAROUSSI, PANEPISTIMIO-GALATSI (4 Km), & HAIDARI-PIRAEUS (6 Km)*

Figure VII.iii shows the lines of Metro.

Figure VII.iii - The Athens Metro Map (www.ametro.gr)

Impact of the Metro operation on transport and environment

The two Metro lines serve 650,000 passengers per day. The existing Athens-Piraeus Electric Railway line (Line 1 - ISAP) carries approximately 415,000 passengers per day. Passengers can perform “combined trips”, thus saving plenty of time on a daily basis.The frequency of trips is every 3 minutes in rush hours and 5 to 10 minutes in non-rush hours. By car in rush hours it takes 35 minutes to drive from ETHNIKI AMYNA to SYNTAGMA, while by Metro it takes only 10 minutes.

Approximately 580,000 passengers use the two Metro Lines on a daily basis. Based on ATTIKO METRO’s surveys and calculations, the Metro’s operation reduced by 70,000 the number of cars entering the city centre or, in other words, it reduced the vehicular traffic by 335,000 vehicular km on a daily basis. This means that there is a reduction at about 84,420 kg CO_2 air emissions per day.

At the same time, the Metro operation was combined with the restructuring of other public transportation modes as well, by reducing the bus terminal stations in the city centre due to the creation of new bus terminal stations close to the Metro Stations. Therefore, the Metro’s operation reduced significantly not only the number of private cars, but also that of buses in the centre of Athens. It is stressed that the Metro’s operation contributed to a 14% increase in the use of the ISAP network as well, thus, reducing even further the use of private cars. As a result, the Metro has significantly contributed to the enhancement of the public transportation modes, to the reduced the use of private cars and to the relief of the centre of Athens from traffic, thus, leading to the improvement of the environment and, mainly, to the mitigation of air pollution in the Attica region.

There is a significant reduction in all pollutants, taking into consideration that the vehicle fleet increases by 6% every year after 2001. Table VII.iii shows the effect of the usage of the Metro.

The positive effects on the quality of the air within the next years will become even more tangible along with the progress of the works and the completion of the Metro extensions, the enhancement of ISAP network and the extension of the Suburban Railway and the Tramway.

Pollutant	2002	2003	2004
Sulphur Dioxide (SO_2)($\mu g/m^3$)	16.6	19.9	18.4
Carbon Monoxide (CO) ($\mu g/m^3$)	2.26	1.93	1.91
Azote dioxide (NO_2) ($\mu g/m^3$)	51.9	50.7	52.2
Ozone (O_3) ($\mu g/m^3$)	49.4	52.9	44.3
Fumes ($\mu g/m^3$)	47	37.5	42.7

Table VII.iv - Air emissions in Athens (www.minenv.gr)

The Metro extensions currently under construction, when complete, will serve 400,000 additional passengers and will further reduce air pollution

Case study 3.2: Solar Village

The Solar Village is located in the region of Pefki, a suburb of Athens. It is a social estate consisting of 435 homes and 1750 inhabitants. It was completed in 1991. It is built with the principles of Bio-climatic architecture and urban planning. It is using solar energy systems and heat pumps to provide heating and hot water for the inhabitants' domestic use.

Figure VII.iv - The Solar Village

Objective of the design

- Reduce the consumption of conventional fuels.
- Restrict atmospheric pollution.
- Improve the inhabitants' “heating comfort”.
- Sensitize the inhabitants to environmental protection issues.
- Averting or containing the adverse phenomena which frequently transform large-scale housing estates into ghettos, and ensuring the quality of social life and the environment in the Village together with the inhabitants' acceptance of the energy systems installed.
- For 3.5 years, field of application (by groups of experts) of the “Scientific Research and Demonstration Program of the Solar Village”.

- **Environmental Impact**

- Coverage of the needs of the population: for space heating = from 15% to 70% for domestic hot water = from 30% to 100%.
- Annual reduction of consumption: 300,000 litres of fuel-oil and 230,000 kWh of electricity.
- Annual reduction of atmospheric pollutants: 300,000 Kg of CO_2, 160 Kg of NO_x and 260 Kg of SO_2.
- Acceptance of the energy systems by the residents - overall average percentage: satisfied persons 84.96% - dissatisfied person 5.44%.

Implementation of the Project

The implementation of the aforementioned project presents the following benefits:

- Operation of a model social housing estate (affordable to families in the medium or low income brackets), with relatively high standards, particularly of “heating comfort”, with green space and infrastructure for social services.
- Satisfactory coverage of the needs of the population for heating (from 15% to 70%, according to the energy systems) and hot water (from 30% to 100%).
- Significantly reduced consumption of conventional fuels (annual reduction of 300,000 litres of fuel-oil and 230,000 kWh of electricity) and a corresponding reduction of atmospheric pollution (annual reduction of pollutants 300,000 kg of CO_2, 160 kg of NO_x and 260 kg of SO_2).
- Acceptance of the applied energy systems by the residents with a high percentage of satisfaction (by 66.67-87.50"/o for the various types of energy systems and with an overall average of 84.96%) and a very small percentage of dissatisfied persons (from 0% a to 19.17"/o - only for 32 homes- and with a total average of 5.44%).
- This acceptance was expressed in the regular payment of the heating and hot water bills, whereas one of the most common forms of dysfunction in OEK estates is the non-payment of common expenses.
- Valuable scientific experience acquired by the groups of experts on the bio-climatic planning of buildings and estates and on the large-scale production and installation of the relevant (among the most successful) energy systems.
- Completely normal human relations in the settlement, with residents who really “care” about their village, with bustling local social life, with a multitude of recreational, cultural, athletic and other social events developed by the inhabitants themselves. These activities made life in the village interesting for the residents, and also attracted the population from the surrounding district, thus functioning as factors promoting social cohesion.
- Safeguarding and visible improvement of the environment, particularly with the individual gardens on the ground floors of buildings and many on verandas.
- Fourteen years after habitation, the Solar Village retains fully its demonstration nature, both in respect of its architectural and urban planning

design as well as of the energy systems installed there and of the busy local social life and preservation of the environment in the community. Indeed, it is a place that university and other scientific groups visit and study, as well as foreign social housing agencies, representatives of municipalities, housing construction companies, manufacturers of industrial solar systems, ecological organizations etc.

Key points regarding sustainability-Achievements

- The long-term evaluation of the S.V.'s energy systems has delivered valuable scientific technical and economic data which have upgraded both the scientific research (experience, software and hardware at universities) as well as the know-how for the solar industry, especially in Greece.
- For the needs of the S.V.'s SRD Programme, a national testing laboratory for solar equipment has been established in Greece. This institute can test the efficiency and durability of solar collectors and systems, and has helped upgrade the quality of solar systems nationwide. Additionally, this institute and the know-how gained through the long-term evaluation of the systems have provided technical and scientific support to the solar industry in Greece. The Greek solar market with app. 1.5 million m^2 of solar collectors installed and strong export activity is one of the largest on a world scale.
- The evaluation results of the bio-climatic urban architecture and the performance of the different passive and active energy systems (solar and heat pumps) and the experience gained through the Project have provided the basis of the remarks submitted by OEK to the national committee drafting a new law on the use of energy in buildings, including the use of renewable energy sources. This law is expected to influence the development of renewable energy sources for the coming decades and is hence very important.
- The SOLAR VILLAGE S.A., which was charged with the management of the Project and operates the energy systems in the settlement, participates in the National Standardization Committee TE-35 for solar energy. It is of great significance to note that through this committee the experience of the S.V. Project is taken into consideration in the drawing up of national standards for solar energy. Furthermore, SOLAR VILLAGE S.A. participates in the working out of international standards and, through its personnel, has been assigned by ELOT (Greek Standards Organization) to the Secretariat of Sub-Committee 5, solar collectors of the technical committee TC-180 of the International Standards Organization (ISO) thus offering the project experience to the elaboration of international standards. It is obvious that the development of international standards is very important in promoting the use of solar energy as they support the exchange of solar products worldwide and codify our knowledge of these systems.
- The acute need to converse energy may have been currently reduced owing to the low energy prices of the 90s. On the other hand, however, the increasing international consciousnesses of the dangers of environmental pollution constitute a factor of increasing interest in renewable "clean" energy sources.This was also depicted on a world scale in the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 or the European Union plans for CO_2 tax and the steadily tightening pollution legislation in a lot of developed countries.
- Another important impact of the S.V. Project is the introduction of central management in housing estates. The S.V.'s energy systems are operated and maintained by SOLAR VILLAGE S.A. which issues bimonthly energy bills for each dwelling to cover the operating costs of the systems. This way, two barriers are overcome:
- The solar and heat pump systems require regular maintenance as they are still new technologies. If (when) the systems are not kept up properly, they often break down. And this can lead to the users' loss of confidence in these systems.
- The centralised management and the relatively reduced operating cost of larger systems with many users, such as district heating, permits their appropriate maintenance and smooth functioning, without disagreements among users.

Conclusions

Within the concept of COST C23 Action, Greece has to present significant moves towards reducing carbon dioxide emissions in the urban built environment. It is notices that the most important air emissions reduction comes from the metro operation. The expansion of metro lines will cause a further reduction. The solar village is an experimental project which combines renewable and conventional energy sources in order to serve the need for better environmental behaviour of buildings. If more establishments apply this policy, then the results will be more impressive. Finally, the Olympic Village with the use of exotic materials and the applying of the green proposals could be a unique lead template of energy saving establishments but unfortunately this use was never implemented due to the pressure and the lack of time.

Although Greece has shown significant delays in implementing EPBD related legislation, 2007 and 2008 have been marked by significant advances. Promotion of renewable energy technologies in buildings as well as defining procedures for implementation of the EPBD have appeared in recent legislation. Still, the methodologies have yet to be fully defined and the responsible legal and practical structures are still under development leaving much work to be completed in 2009.

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VIII Italy

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National context

Italy is a parliamentary republic with a total population of nearly 60 million inhabitants on a surface of 300,000 km^2. Rome is the Capital. It has been member of the European Union from 1957 (charter member). By an administrative point of view, it is divided into 20 Regions, five of them are autonomous. It is placed between the 47° and the 36° North parallel, more or less in the middle of the temperate zone in the Northern hemisphere. It has a prevalent north-south development, going from the mountainous regions of the Alps (near the Austrian, Swiss and French border) to the middle of the Mediterranean Sea, not too far from the Tunisian coasts in North Africa. It could be considered a "trans-national" country. The 41.6% of the whole territory is hilly area, while the 35.2% is mountainous and the 23.2% is flat. The coastline is 7,500 km. The EPBD has been adopted by the Italian Parliament with the Decree-Law 19 August 2005 n. 192, corrected and integrated with the Decree-Law n. 311/06.

Climate

From a climatic point of view, Italy is favoured by the great water mass of the Mediterranean seas by which it is mostly surrounded. The seas are beneficial acting as heat and humidity tank, and they determine a particular climate called "temperate Mediterranean". Another characteristic is that the country is divided even longitudinally by the Apennines, determining important differences between the East and West coast. Generally speaking, Italy can be divided into 4 climatic zones:

- alpine climate, concerning the Alps and the northern-central part of the Apennines, characterized by low night and winter temperature values and rainy summer days;
- Mediterranean climate, concerning the two great isles of Sicily and Sardinia as well as the Southern part of the country, characterized by mild temperature values and a rainy winter season;
- peninsular climate, concerning the central part of the country, characterized by mild temperature values (except on the Apennines where the situation is typical Alpine) and rainy days most in Spring and Autumn;
- the Po Valley climate, a particular zone protected by the Alps (North) but exposed to the sea (South), characterized by a great yearly temperature swing (low values during winter and high values during summer), a great humidity and rainy days most in spring and autumn

Due to the great differences mentioned above, Italy is divided into 6 climatic zones depending on the heating degree days (going from 5165 in Sestriére to 568 in Lampedusa).

Demographics

After the population census of 2001, the national population was 56,995,744 inhabitants (189 inhabitants/km^2), 59,829,710 registered by ISTAT (central statistic institute) in June 2008. The 18.68% of Italian people is over 65 years of age. The average number of members per family is 2.59. The percentage of foreigners was 2.34, 5.73% in June 2008. The biggest city is Milan (3,707,210 inhabitants), followed by Rome, Naples and Turin. During time, the number of elderly people has slightly increased, changing the so called age pyramid. The continuous increase of the population is mostly due to immigration.

With respect to the building sector, there are 21 million families having at their disposal 26.5 million houses (for a total volume of 5.5 billion cubic meters of living spaces), 9 million of them are single-family or duplex houses. Among them, 17.5 million (66%) have been built before 1973 and so designed with no attention to energy saving issues. Non-residential buildings are more or less 1.9 million: 0.8 million for manufacturing, 0.22 for the service sector and the others with different use.

Economic features

Italy is member of the G8 group having the eighth larger economy in the world. In 2007 GDP was €1,535 billion with a great public debt of €1,599 billion (ratio debt/GDP 104.1%); the per capita GDP was €30,365. The production system is made of a lots of small companies. There are few large companies usually managed by only one family (as FIAT with the Agnelli dynasty), while the public company system is almost nonexistent. There are however differences between the situation in the Northern part of the country, characterised by strong industrial development and mostly private companies, and the Southern one, with unemployment rate up to 20%, mostly national industries and an agricultural system. Tourism is still a very important sector.

Energy features

Some numbers concerning energy use in the building sector (2000).

- Energy consumption in the building sector (manufacturing process): 7.2 Mtoe of combustible and electricity, 11 Mtoe of primary consumption.
- Primary consumption for the building use: 70.1 Mtoe = 38% of the national primary energy needs.

The sum of the previous two is 81 Mtoe = 44% of the total energy national needs.

In the residential sector, the greatest energy wastage is due to the very poor quality of the building envelope. More or less the 2/3 of existing buildings have been built before the law 373/76 about thermal insulation and energy systems. Even nowadays there are 13 millions of autonomous heating systems (a lot of them are electric boilers even if 400 thousand of them are replaced every year), consuming a greatest amount of energy compared to the centralized ones.

The existing situation can be deduced from the Enea Report 2006 (Italian National Agency for New Technologies, Energy and the Environment). First of all, in 2005 there has been a limited increase of total energy use, among which the total request of oil-derived energy has diminished even if it remains the main energy source (*Figure VIII.i*). But the use of natural gas is increasing while coal and imported energy is decreasing (*Figure VIII.ii*). Unfortunately, even renewable are decreasing, but this is due to the fact that more than the 80% is hydro, and it depends on seasonal factors.

The total increase in energy demands is due to the building sector (residential and service one) due most of all to the changing of climate conditions. Heating and cooling needs are increasing, the last one especially in the last 3 years (with a peak in 2003) due to longest hottest period and to the change in comfort habits.

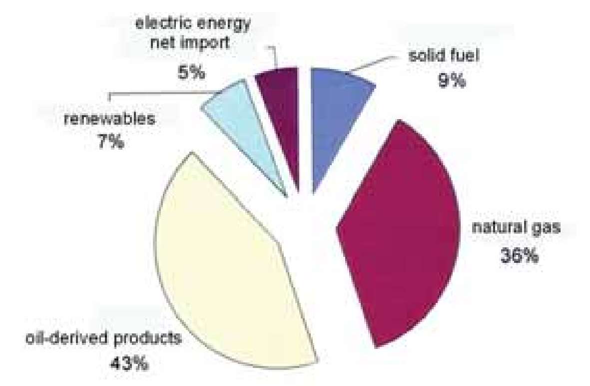

Figure VIII.i - Source energy consumption in 2005

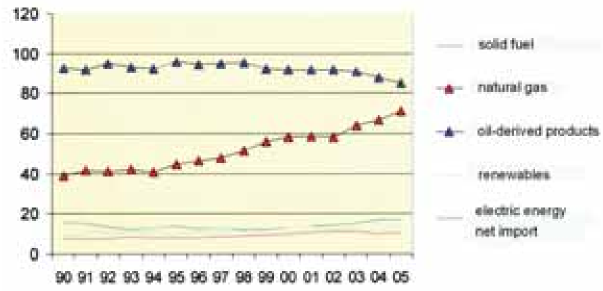

Figure VIII.ii - Source energy consumption – trend 1990-2005

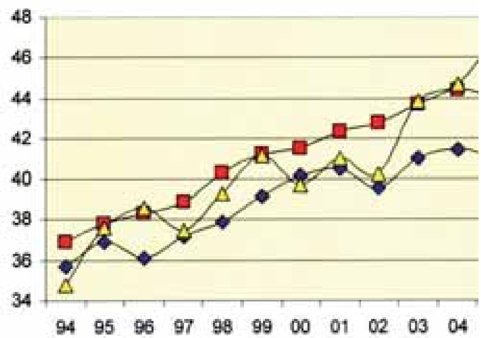

Figure VIII.iii - Final use sector energy consumption – trend 1994-2005

Carbon dioxide emissions

In *Figure VIII.iv* the emissions of CO_2 in Europe (EU-15) and in Italy in the period 1990-2003 are shown and compared. While in Europe a positive trend of +3.8% referring to the 1990 values is estimated, in Italy the increase is of 13%. In the EU-15, Italy is now the third most important producer of CO_2 after Germany and UK with the 14% of total emissions. In particular, compared to Italy, in Europe there is an extensive use of coal, nuclear power (forbidden in Italy) and renewable energy sources.

Considering per-capita emissions, in the last decade the value has grown in Italy, even if slowly, while it has decreased in EU-15.

In *Figure VIII.v* the trend of CO_2 emissions in macro-sector is shown. It is possible to notice that the emission of energy industry has increased a lot (+21%) with an upside down trend, while the one concerning transportation sector has increased constantly (+ 23.7%). The emission due to the building sector also increased of 10%, while those of manufacturing industries decreased due to the better and more efficient technologies used.

	1990	1992	1994	1996	1998	2000	2002	2003
Europa (EU-15)	3146	3110	3059	3174	3157	3149	3208	3267
Italia	403	401	389	413	429	434	441	457
Italia % su EU	12,8	12,9	12,7	13,0	13,6	13,8	13,7	14,0

Fonte: Agenzia Europea dell'Ambiente, 2005

Figure VIII.iv - Emissions of CO_2 concerning the energy system in Europe – years 1990-2003

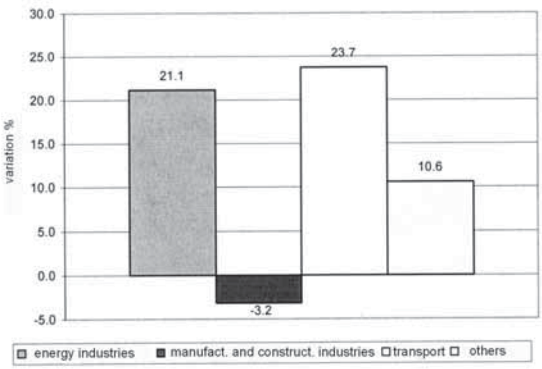

Figure VIII.v - Trend of CO_2 emissions in macro-sector in Italy

EPBD Implementation

From 1998, the Decree-Law 31.3.1998 n. 112 gives to Italian Regions and Autonomous Provinces a strategic function for what concerns energy planning at a local level, giving them the possibility to legislate on energy management issues (for example, in the Autonomous Province of Trento there is a local Law concerning the low energy consumption and low environmental impact buildings, in the Autonomous Province of Bolzano a local law introduced the new energy standard CasaClima based on the passive house standard. Other examples are Regione Lombardia - Regional Law 39/04, Regione Lazio - Regional Law 15/04 and Regione Toscana - Regional Law 25/05, that introduced some specific energy standards).

The EPBD has been adopted by the Italian Parliament with the Decree-Law 19 August 2005 n. 192, corrected in integrated by the Decree-Law n. 311/06, that better represents the spirit of the Directive even with the proposition of more structured intervention both on the new and on the existing buildings stock. In particular, the main articles are:

1. Adoption of a calculation methodology (Article 3)
In a transitory phase, the calculation methodology proposed by the previous National Law n. 10/91 has been confirmed, and it is based on existing national technical standards (CEN and UNI-CTI: Italian Standardization Institute and Italian Thermotechnic Institute).

In particular, the following indexes must be verified:

- winter energy performance index (higher than a value depending on the shape factor of the building - Surface/Volume ratio - and on the climatic zone)
- U-value of the envelope components both opaque and transparent (lower than defined values depending on the climatic zone)
- average global seasonal efficiency coefficient of the heating system (higher than a value depending on the rated power of the generator(s)).

The calculation could be based even on standards proposed by other national institutes (as National body for alternative resources, Universities or Research National Council) if the results are equivalent or more restrictive than the CEN and UNI ones.

2. Setting of energy performance requirements (Article 4)
The law is applied to:

- design and realization of new buildings and their systems, new systems in existing buildings (exception: non residential buildings heated for some specific needs or with refluent of the productive process, and stand-alone buildings with a total useful area lower then 50 m^2)
- existing buildings in case of a complete renovation of the envelope or of extraordinary maintenance actions with a total useful surface higher than 1000 m^2 or concerning a volume increment more than 20% of the existing one (exception: preserved historical buildings, a decree is expected on this issue);
- existing buildings in case of enlargement and installation of new systems in existing buildings.

3. Energy performance requirements for new buildings (Article 5)

They will be defined by Implementation Decrees to be issued. In a transitory phase, some requirements are prescribed based on the shape factor of the building - Surface/Volume ratio - and on the climatic zone, consisting of:

- a minimum winter energy performance index.
- a maximum U-value of the envelope components (both opaque and transparent).
- a minimum average global seasonal efficiency coefficient of the heating system.

For all new buildings, it must be verified:

- the absence of inner and surface moisture phenomena in external walls (except for manufacturing buildings).
- the possibility to adopt natural ventilation strategies (except for manufacturing and sports buildings).

For all new buildings, it is compulsory:

- to adopt external shading elements (if the total useful surface area is higher than 1000 m^2, except for manufacturing and sports buildings).
- to provide a minimum value of the superficial mass of the external envelope elements so to provide an adequate thermal inertia. As an alternative, new materials and elements can be used, with thermal characteristics certified by accredited laboratories.
- to install special devices for the temperature control of single rooms or zones so to avoid overheating.
- to use renewable resources for the production of thermal and electric energy. In particular, the 50% of annual hot water requirements must be produced in this way (20% for buildings in historical centre).
- to provide the building with photovoltaic panels for the production of electric energy
- to provide the building with the possibility to connect to the district heating system if nearest than 1 km or planned in the future.

From the 1st July 2007, all new and existing buildings (in case of a complete renovation of the envelope or of extraordinary maintenance actions with a total useful surface higher than 1000 m^2 or concerning a volume increase more than 20% of the existing one) must be provided with an energy performance certificate by the end of the construction. The certificate must be provided by the building company. The energy performance certificate is valid for maximum 10 years, and must be updated after each intervention on the building or its system(s). The training and education of independent experts is delegated to the Regions and the Autonomous Provinces, depending on their economic and human resources and on their legislation.

Case Study 1: Vieider House

Context

Vieider house is situated in the Autonomous province of Bolzano in the Trentino Alto Adige – Südtirol Region. The Region is an Autonomous Region placed in the northern part of Italy, near the Austrian border. It is divided into two Autonomous Provinces (realising a kind of autonomy inside the autonomy): the Autonomous Province of Trento (or Trentino) and the Autonomous Province of Bolzano (or Alto Adige - Südtirol).

The building

Figure VIII.vi - Vieider House

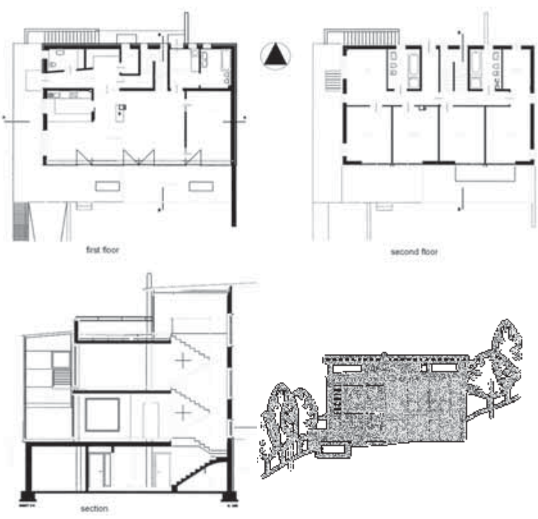

Figure VIII.vii - Plans, section and facade

Owner: dr. Martin Vieider and his family
Designer: arch. Kurt Egger - Egger-Aichner-Seidl office (Brunico – Italy)
Year: 1999-2000

In Alto Adige – Südtirol a particular standard called CasaClima (KlimaHaus) has been introduced, giving a certificate to those buildings with a particular high energy efficiency. A special plate KlimaHaus plus is assigned to those buildings that are highly efficient by an energetic point of view and that at the same time meet some eco-compatible requirements, between which total yearly heating consumption lower than 50 kWh/m^2, no use of fossil fuel energy, no use of synthetic insulating material (or containing harmful fibres), reuse of rain water, no use of PVC floors, windows and doors, no use of chemical materials for wooden elements, colours or paints containing solvents in indoor spaces, no use of tropical wood.

Regarding site selection, the building is at an altitude of 1050m above seal level and it is placed on a gentle slope sliding down towards a large plain and facing the south and west direction. It stands alone, i.e. no building around for about 50m. The choice is due to the fact that the land was a property of the owner, no other reasons. But it is important to notice that the owner himself asked the architect a bioclimatic and wooden building with a large sunspace, because he likes the sun, the landscape and the typical smell of wood.

The building has been designed following sustainable principles and green architecture criteria. First of all, particular attention has been paid to the room positioning: the served rooms, that is the ones used during the daily activities and the sleeping period, have a southern exposure, while the serving ones (kitchen, bathrooms, box rooms and stirs) have a northern exposure. A particular attention has also been paid to the use of renewable energy sources (like the sun), following these particular designing criteria:

- wide windows facing south (59% of the total wall area), in order to maximize the solar irradiation during the winter period (sun low in the sky) and to guarantee a good heating and lighting contribution even during the coldest and darkest months of the year; during the summer period, the sun is high above the horizon and the solar irradiation is more or less perpendicular to the building, and the roof acts like a screen for the inner spaces;
- main walls facing east, west and most of all north with wide opaque surfaces and small glass openings, in order to minimize the heat losses through the window frames;
- presence of darkening movable elements for the southern windows (in order to let the users control the solar irradiation depending on their needs) placed outside so to avoid possible overheating problems of the inner spaces due to the heat loss of the thin plate that constitute the elements;
- designing of a sunspace used as storage heater during the winter and as heat barrier during the summer;
- presence of a concrete wall positioned against the ground on the east side and a bed rock (a layer of gravel 15 cm thick in each slab), used as storage heater.

The heating system is reduced to the minimum, and it is made up of a pellet stove used to heat the large room at the first floor and a water tank of 800 litres, with the help of 10sm of conventional solar panel. The ventilation is guaranteed by an automatic system that draws air from an opening placed 35 metres north of the building and that channel it along an underground duct (with a diameter of 150 mm) to a heat exchanger placed in the building basement. During the summertime, the hot outside air get cold underground and it is blown inside the rooms, while during the wintertime the outside cold air get warmer both underground and in the heat exchanger (meeting the air exit the building) reaching the temperature of about 18°C.

The building has been realized with particular attention to the use of natural and recyclable materials, with a low environmental impact regarding the LCA.

The main structure is made of bearing wooden panels composed by (from the backing to the outer side) clay panel (1.5 cm), wooden bearing panel made of crossed planks (9.5 cm), insulation of pressed natural fibre (22 cm), ventilation space (3 cm) and finishing of deal planks (2.5 cm). The outer walls have a design (planned) U-value of 0.15 W/m^{2}K. The windows are made of a larch wooden framework with a three layers glass panel with Krypton among them, for a final design (planned) U-value of 0.70 W/m^{2}K. Considering the design data, the building should have an estimated annual space heat requirement of 30 kWh/m^{2}a, and it can be considered as a so called low energy building (while a passive house is a building with an annual space heat requirement of less than 15 kWh/m^{2}a).

Management

The building has been monitored by the University of Trento for one year by means of a continuous thermal survey during real life conditions in the period October 2003 – September 2004, plus some periods in spring 2005, in order to evaluate the real influence of passive systems on the building performance, releasing it from the heating system and its use, and to analyze the real comfort conditions of the users.

Data of the temporal courses of some specific environmental parameters (air temperature, relative humidity, air velocity, globe temperature, walls surface temperature) related to the most used thermal comfort indices (PMV and PPD) in some rooms of the building, chosen to be representative of different indoor conditions and exposure, have been recorded.

Generally speaking, it has been possible to notice that the sunspace indoor temperature well follows the trend of the outdoor one, but reducing its peak up to 10-16 °C, and this have positive repercussions on the room temperature. However, the indoor temperature has a wide daily swing, and this can cause discomfort conditions depending on the user activity and clothing. Moreover, it can determine problems in the psychological adaptations in the form of thermal expectations because nowadays we are used to control the indoor environment keeping a constant temperature all over the day. The differences of the environmental conditions in the rooms with a southern and a northern exposure are very low (and this is due both to the super-insulation and to the corridor acting as a buffer zone), while they are higher between the first and the second floor, with differences during the summertime up to 3°C. This is probably due both to the natural convective motion of warm air inside the house and, most of all, to the huge sunspace.

In order to deepen the real thermal comfort levels inside the building, PMV and PPD indices (Fanger 1970) have been considered taking into consideration three different activities: day light (1.2 met), day heavy (2.6 met) and night (0.8 met) with three different clothing: light (0.56 clo), heavy (0.86 clo) and night (1.8 clo). The relax and sitting room temperature has an high daily swing and this cause a certain discomfort during the daytime most of all for heavy activity (for example cleaning) and during the first morning due to low temperature values. The bedroom temperature swing is lower and, even if the minimum value seems to be quite high, the low relative humidity allows comfort levels during the night keeping the PPD under 5%, while daily temperature is too high even for light activity (PPD of 30%) and unbearable with heavy clothing (PPD up to 70%).

It is important to notice that the users manage the building and its systems by themselves, i.e. without any scheduled operation scheme, but only basing their behaviour on their personal sensations. In this respect, the owner wish to have an automatic system to control the inner thermal conditions, for example a computer based system like in the intelligent buildings (a so called home automation system). The data collected during the monitoring confirm the user perception. In fact, they experienced an inner hot microclimate during spring, and it is on their own to properly manage the shadowing devices. However, it must be noticed that the owner is very motivated, and so he is interested himself in operating the building properly and in respecting the environment.

Performance criteria

For what concerns the performance criteria, when the building has been designed and built the National Energy Law n.10 was into force. The Law 10/91 is a so called "outline law", referring to implementation decrees its real application. In particular, for what concerns the building sector, the implementation decree is the Presidential Decree (DPR) 26/08/93 n. 412. It faces the energy saving issues in buildings considering the balance of the entire system building-plants. It states that in order to keep adequate inner environmental conditions it is important to control the thermo physical characteristics of the building envelop and of its parts, but even the systems and the trapped heat.

It divides between primary energy (combustible and electric energy) and trapped heat (solar radiation, artificial lights, people and so on). In order to control energy consumption, it is important to minimize primary energy consumption. This is possible acting on three factors:

1. the thermal insulation of the building and its parts;
2. the systems;
3. the trapped heat (solar radiation on opaque surfaces, on windows and so on).

The DPR requires the verification of three indexes:

a. Cd: energy dispersion coefficient through the building envelop
b. μg : average global seasonal efficiency coefficient of the heating system
c. FEN: normalized energy requirements of the building

For what concerns Vieider House:

1. $Cd,lim = 0.560\ W/m^2K > Cd,vieider = 0.343\ W/m^2K$ => OK
2. $FENlim = 89.72\ KJ/m^3d°C > FENvieider = 6.918\ KJ/m^3d°C$ => OK
3. $\mu g,Vieider > \mu g,lim$ => OK

For what concerns the elements of the envelope, a thermography of the four external walls has been made, together with the survey of the roof and some inner elements, with the following results:

1. outer walls:
   U value-planned = 0.15 W/m^2K
   U value-measured = 0.19 W/m^2K
2. windows:
   U value-planned = 0.70 W/m^2K
   U value-measured = 0.98 W/m^2K

The difference between the planned values and the measured one, less than 30%, are acceptable because it is not right to consider the thermal conductivity λ-value of the material declared by the producer during the design process, but it should be better to use a value modified in order to take into consideration the real condition of use and the way the elements have been laid (often not the correct or optimal one). The Italian standard UNI 10351 "Building material – Thermal conductivity and water vapour permeability" states that the differences between the values measured on laboratory samples and those traceable in the current production can range from 5 to 50%. A corrected λ-value is proposed taking into account the percentage of humidity inside the material in usual condition, the ageing, the constipation of loose materials, the handling and the installation with workmanlike, the measures tolerance. The increment coefficient is variable from 10 to 50%, sometimes even 100%, and it depends on the material considered.

Cost analysis

For what concerns operating costs, the energy consumption of the systems was recorded in 2004. The electricity consumption (final use) was of 3,249 kWh corresponding to 14.06 kWh/m^2a and to a primary electricity consumption of 42.2 kWh/m^2a. 1900 kg of pellets have been used in the stove (air and water heating) corresponding to about 1.65 m^3 and so 5,635 kWh/m^3. In the end, we have that:

- heating energy consumption = 37.42 kWh/m^2a
- space heating energy consumption = 32.16 kWh/m^2a
- space heating energy consumption (primary) = 32.16 kWh/m^2a, being the wooden pellets considered carbon neutral

So, the total energy consumption has been of 51.49 kWh/m^2a and the total primary energy consumption of 79.62 kWh/m^2a. We must taking into account that, considering the year 2000:

1. the average energy consumption values (normalized on the degrees day) in Italy was of 157.6 kWh/m^2a (90.7 in Spain, the minimum, and 198.8 in Ireland, the maximum);
2. the heating energy consumption in Italy (residential sector) was of 109 kWh/m^2a.

Vieider house can be considered a low-energy house (heating energy consumption among 25 and 60 kWh/m^2a, total energy consumption near 75 kWh/m^2a).

Carbon analysis

As a first attempt, the simple following calculation can be made. Taking into account a statistical value concerning a national (Italian) average related to 2004, for every kW used in a building, 580 g of CO_2 are sent out in the atmosphere. So, the CO_2 emissions of Vieider House due to electricity is:

$$14.06kWh/m^2a * 580g/kWh * \text{total heated area} = 1825.69\ kg/a$$

For what regards the heating system, the CO_2 emission of the wooden pellets is about 55g/kWh and so the CO_2 emissions of Vieider House due to heating is:

$$37.42\ kWh/m^2a * 55g/kWh * \text{total heated area} = 461.14\ kg/a$$

In total, every year Vieider house contributes to the environment depletion with a total emission of 2.28 tons of CO_2.

To tell the truth, it should be taken into consideration that Trentino Alto Adige – Südtirol produces its own energy needs using hydro-powered plants, and so the CO_2 emissions due to electricity is near zero. But the calculation has been made on a national base in order to be more representative of a general situation.

CO_2 emissions in the construction phase and the ones during the future demolition phase should be taken into consideration. A precise calculus has not been made, the LCA analysis should be used. However, Vieider House has been built using timber for the bearing wooden panels and for the widow-frames, as well as natural material for the insulation and the finishing. It should contribute to lower CO_2 emissions and the pollutants release in air, in water and in soil during the whole life of the building.

Case Study 2: Zero Energy House

The Gruppo Polo – Le Ville Plus building firm from Cassacco (Udine) and the University of Trento are developing a prototype of a smart green building where a family of four people will live and that will be monitored for one year to check the correspondence to the project purposes.

The total cost of the research project, included the construction, has been financed by the Friuli Venezia Giulia Region and by the Gruppo Polo – Le Ville Plus. The building is called "casa energy zero" (*Figure VIII.viii*) referring to the fact that it does not use energy coming from conventional nets or from non-renewable sources mainly of fossil origin.

In addition the building is classifiable as autonomous house because the consumed energy is produced in situ by alternative and clean sources. The main features of this smart green building are:

- carbon neutral;
- built with renewable materials and innovative building elements producing clean energy (sunspace, LVP intelligent window®, etc.);
- low energy consumption and with bioclimatic characteristic;
- integration between energy systems using alternative and clean sources;
- use of intelligent systems to manage clean energy sources in order to guarantee both inner environmental comfort and energy saving.

Figure VIII.viii - Rendering of Zero Energy House

In order to test and validate the research expected results, the theoretic behaviour of the prototype hypothesized during the design phase will be compared with the continuous on site monitoring of the functioning and performance of the active and passive systems, paying attention to the energy saving and the users' comfort conditions. The building will be completed in Autumn 2009 when the monitoring and evaluation phase will start.

The bioclimatic concept

For what concerns the bioclimatic strategies, the building (design by arch. Arnaldo Savorelli – Solarch Studio in Bussolengo – Italy) presents both passive elements for winter heating and for summer ventilation and cooling. First of all, it must be noticed the particular position of the construction inside the building site, situated at the northern side in order to let the widest part of the garden and the livable spaces directed to the South. The whole shape is interesting and studied in accordance with the local climate. The main body of the house, in fact, has a compact rectangular plant with an unique roof pitch facing the North with a double result: to protect the house from the northern cold winter winds and, in the meantime, to expose the widest part of the southern façade to the warm sun radiation during the cold season. Moreover, there is a little difference in altitude from the main roof and the secondary one on a lower level: it allows the presence of several little windows at the top of the building that, being inaccessible from the outside, can be left completely opened even during the night in order to guarantee a proper ventilation of the inner spaces during the warm season.

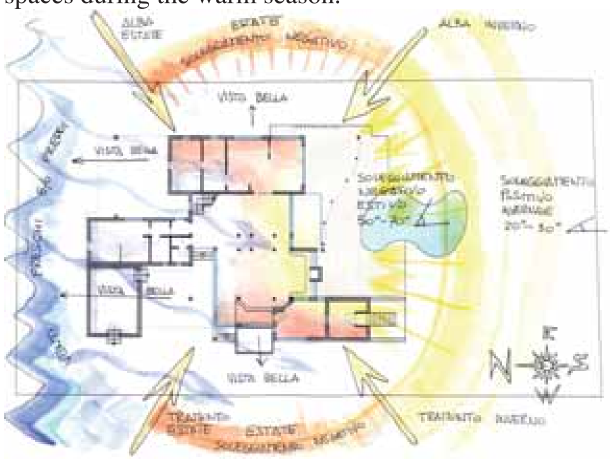

Figure VIII.ix - Strong relationship between the building and the natural environment

The southern façade, facing the garden and the pool, is a wide glass surface that takes advantage of the sun irradiation and let it enter the house till the back of the space during winter, while in summertime it is shaded by overhangs and provided with brise-soleil in order to avoid over irradiation and glare phenomena. In addition, a sun space and a Trombe wall are present.

The northern façade, on the contrary, has little windows most of which are used just for summer night ventilation and to allow a proper views to the north side of the landscape.

The façades facing East and West have themselves bioclimatic features, presenting low windows but large enough to let the user be delighted of the outer space without causing discomfort coming from the apparent daily sun path. Moreover, adequate shadows are provided.

Figure VIII.x - Structure of the external wooden wall under construction

The building technique

The prototype is a timber framed building with external and internal timber walls. The building is built with natural and renewable materials except for the hardware of the carpentry that is in steel. For this reason the building is classifiable also as natural building.

Actually in Italy there are few timber buildings, but their construction is increasing for the raising consciousness of users in relation with environmental issues and green buildings. In Italy, the majority of timber buildings are built with panel systems borrowed from Austria. Only few systems are planed and made in Italy, most of all with handmade systems.

Here, a framed system has been considered that could be produced with industrialized techniques and that is completely designed in Italy by the Gruppo Polo – Le Ville Plus with the support of the University of Trento. The choice of this building system instead of a panel one is due to the greater building tradition in framed construction, also if limited to the Italian Alpine Region. In addition, it allows a higher constructive flexibility and it is easier to adapt to different configurations, even if the various building components are made with industrialized processes. The pillars have a square cross-section 16x16 cm, they are connected to the basement by steel structure and steel plug. A knee wall connects together all the posts and it closes the frame. The main beams and the secondary beams (used sometimes as wall plates) are in glue-lam with a square cross-section 16x16/24 cm. The intermediate floor and the roof are built with glue-lam beams with a square cross-section 8x24 cm and a step of 50-80 cm. In both cases, the floor is built with board and insulation materials. In particular, the roof floor has a U value (thermal transmittance) of 0.197 W/m^2K. The external walls are made up by thermally insulated elements and by timber panels. With this kind of wall it is possible to reach a value of thermal transmittance of U=0.192 W/m^2K. The basement is a crawl space finished on the extrados by a reinforced-concrete slab. In this way concrete volume, which has a great heat capacity, can accumulate energy to help the heating system in the winter season.

The inner walls have a timber framework and plasterboard cladding. Wood fibre, a natural insulation material, is positioned in the free space between the frame grid. Nowadays, in Italy the most diffused type of inner wall is built by steel section and plasterboard cladding. This solution is in contrast with the natural house concept because the steel section set can determinate a Faraday cage that can reduce the inner environmental quality for the presence of electric charges that cannot be disperse. In the prototype, a new type of inner wall will be tested that has not this problem because the frame is in timber and the elements are made by industrialized processes. The horizontal elements are lists 40x60 mm, the posts are two coupled lists 30x50 mm.

Another innovative element planned in this research, is the LVP intelligent window®. It is built by two glazed panels with an inter-space of 30-45 cm (depending on different solutions). Each panel has two openings with a flap putted on the top and on the bottom. In order to improve the air circulation in the inter-space, a small fan is positioned in the lower part. The fan is operated by a small electric motor powered by a small photovoltaic system. The opening and the closing of the flaps manages the circulation of the air inside the inter-space. In this way it is possible to run warm air into the house during winter, taking advantage of the greenhouse effect. In the same way, opening the opposite flaps it is possible to extract warm air from the inner space incrementing natural ventilation. The flaps are managed by the intelligent supervision system of the house and the opening/closing is totally automatic depending on inner and outer environmental conditions (especially temperature values).

The intelligent system

The smart solutions implemented in the prototype building focus on the followings main goals:

- to test and verify the utility and the effective use of scenarios for the flexible utilization of automated passive solar systems;
- to quantify the contribution of automated control for the lighting, shading and conditioning systems;
- to experiment the possibility to guarantee both safety and security to the house users.

The devices and the correspondent functionalities of the smart system have been specifically established, in order to manage the interactions of all the technological system components in compliance with the peculiar issues of the prototype. In particular the following input devices have been included in the smart system design: temperature and humidity sensors, magnetic contacts to check the opening or closing state of the windows, occupancy and movement detectors, illuminance sensors (IEA, 2000).

Each device will be connected with a weather station in order to monitor the outside climate conditions (temperature, illuminance level, wind speed, rain) and with supervision touch screens in order to visualized and control the parameters available on the bus.

The sunspace of the building is completely automated. It is a passive solar system, used mainly to heat the indoor spaces in the winter season. The automation system gives a specific signal about the proper functionality mode based on the outside weather conditions specifically connected with the proper use of the sunspace in winter season and with its complete opening in summer time. The implementation of its functionality program has been previewed in two specific temporal modalities: seasonally and daily running function. The functionalities of the smart system for the sunspace are:

- automated control of the opening/closing system of the windows, in order to optimize the convective fluxes of the air and the temperature level not only inside the sunspace but also in the adjacent rooms (automated control and priority of the manual operation);
- local and remote visualization of the windows opening/closing state and of the sunspace shading system according with the best position dynamically calculated;
- detection of the temperature values in the sun space.

The cooling system of the building is based on natural ventilation strategies. The functionality of the automation system for the natural ventilation improvement in the inner space is focused on the activation and the trigger action of the windows automated opening system. The main input parameter of this regulation function is the local detection of the inside temperature in order to support the air fluxes. The opening modalities of the opening systems are the same described above for the sunspace.

The building is equipped with shading systems. Their automated control is applied in different complexity levels: from the simple motorized action of the shading system to the complex control of smart shading systems, able to change properly the brise-soleil position according to indoor and outdoor environmental conditions (temperature and illuminance level). In this way, by means of the automation control system, it is possible to adjust both the slope level (angle of descent) of the brise-soleil elements and their movement speed (step by step or up and down). The heating system of the building is controlled by the automation system. It is previewed, indeed, the integrated control of the heating system by means of the simultaneous use of radiant heating, solar panels and pellets boiler with height efficiency (the so called “integrated fireplace”). The whole system is regulated using a supervision system with seasonal mode. It is based on the subdivision in thermal zones of the radiant heating system.

The smart functionalities of the control system for this specific application involves the integration of the radiant heating with the solar panel, the proportional opening in continuous of the thermal valves of each single zone, the separate and differentiated activation of each defined thermal zone and, at least, in addition, the possibility to get, a remote control of the whole heating system.

The photovoltaic panels are connected to the automation system only for what concerns the data related to the hourly production of photovoltaic energy. It is indeed useful a comparison of these data in relation with the weather parameters values recorded by the outdoor weather station, correlated with the sun position and the sky conditions. Significant data about the daily use of the building elements are controlled and monitored by the bus net of the devices installed. The supervision system allows indeed not only the recording of environments parameters but also the users’ behaviour analysis. With these data it will be possible to improve the theoretic model of the building analyzed in relation with both weather conditions/building constructions characteristics and the user' action in real use situation.

Conclusions

The two case studies presented (one concerning an existing building and one an advanced research building now under construction) aim to point out some important issues that should be addressed in order to control energy use and so CO_2 emissions.

1. First of all, it is very important to control the quality of the building envelope. In Italy, in the last years only the 20% of the constructions built before 1973 have been restored. But requirements on the envelope elements are becoming more demanding. With the Legislative Decree 311/2006 some limits are given concerning the U-value of walls, roofs and windows, decreasing from 2006 to 2009 and 2010 depending on the climatic zone. Even if something more could be done, this is a first step.
2. Use of passive devices for heating and most of all cooling. For example, natural ventilation and passive cooling in order to control summer air conditioning. By a technical point of view, it is not still clear how to calculate energy needs for summer cooling, and it is especially due to the uncertainties concerning the role of building elements and building materials on thermal inertia. Recently some rules have been proposed taking into account the thermal capacity of the building envelope (by means of a time constant λ depending on the envelope thermal resistance and thermal capacity), but more studies are necessary. Moreover, little attention is given to the relationship between the building and the surrounding environment in terms of exploiting natural elements, above all the sun and the wind.
3. Use of building automation systems, towards the so called "intelligent building". These devices could help the users in a proper management of the building and its systems, both the active and the passive ones, increasing energy saving and a rational use of environmental resources together with better human comfort conditions in indoor spaces.
4. Use of renewable together with new and more efficient systems. Along with the classical solar thermal and PV panels, there are new promising technologies as concentration solar thermal with parabolic collectors, wind energy (electric energy production with wind plants is 20% in Denmark, 6% in German and Spain, while it is only the 0.5% in Italy), biomass for domestic heating and the production of electric energy in centralized plants, the use of energy grid distribution systems.

   In the domestic sector, some "new" system could be better used, as geothermal with heat pumps or floor and ceiling heating for example, not common in Italy. Together with some "border systems" as hydrogen domestic boilers or solar cooling devices, for example.

5. Adoption of a building rating system. With the L.D. 192/2005 and the L.D. 311/2006 the adoption of an energy rating system has become compulsory even in Italy. The idea is to establish 7 classes, from A to G, from the more energy efficient building to the less one, including heating, cooling and electric energy use. There are two major issues to be faced: who are the qualified technicians that give the energy certificate and the setting up of proper training courses.
6. Increase material recycling and diminish the production of waste, together with a better and more rational use of drinkable water.
7. Use natural and local materials (in terms of LCA and so of the amount of soil, water and air pollution level) for building construction.

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IX Lithuania

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National context

Lithuania is a Central European country, situated in the very centre of Europe, on the eastern coast of the Baltic Sea. It lies on the Eastern European Plain, with characteristic lowlands and hills (the highest point in the country is only 293 metres above the sea level). The area of Lithuania is 65,300 km^2, and its Baltic coastline stretches for 90 km. Lithuania extends 373 km from the east to the west and 276 km from the north to the south. The geographical co-ordinates of Lithuania extend between the latitudes of 56º27' N (northern extremity) and 53º54' N (southern extremity), and between the longitudes of 20º56' E (western extremity) and 26º51' E (eastern extremity). The border with Latvia is 610 km long, with Belarus 724 km, with Poland 110 km, and with Kaliningrad Region of the Russian Federation 303 km. The territory of Lithuania lies in the northern part of the temperate climate zone. The distance from the equator (6100 km) and from the North Pole (3900 km) determines general solar radiation flux and atmospheric circulation patterns over the country.

Climate

According to the general classification of climate, almost the entire territory of Lithuania is assigned to the south-western sub-region of the continental forest region of the middle latitudes of the Atlantic Ocean, because its climate is close to that of Western Europe; while the Baltic coast is assigned to the South Baltic sub-region. The average annual temperature in Lithuania fluctuates from between 6.5 and 7.1ºC at the seacoast, to 5.5ºC in the northern part of the country. The average temperature is – 4.9ºC in January and + 17ºC in July.

Summer is warm with relatively mild weather in spring and autumn. Winter, which lasts from November to mid-March, can be very cold. Rainfall is distributed throughout the year with the heaviest rainfall in August. Heavy snowfalls are common in the winter months.

Demographics

At the beginning of 1998, there were 3,704,000 people in Lithuania. Out of this number, 2,525,200 people lived in towns and 1,178,800 in the countryside. In 1998 the population density was 56.8 persons per km^2.

Economic features

Lithuanian economics have declined substantially after declaration of independence in 1990. In 1994 GDP dropped to 54% of 1989 level but later started to increase again. GDP growth reached 7.3% in 1998 but, as a result of banking crisis in Russia, decreased again in 1999. Since 2000, GDP is growing continuously, average annual increase in 2000-2005 was 7%, average GDP change from 1995 to 2005, including the decline during the banking crisis in Russia, was 5.7%.

Carbon dioxide emissions

Between 1990 and 2000, greenhouse gas (GHG) emissions decreased significantly as a consequence of the reconstruction of the economy: the decline in industrial production engendered a sharp decrease in fuel consumption and as a result, in greenhouse gas emissions. Once rehabilitation of the economy started, reductions were also achieved through energy efficiency and measures taken to reduce emissions. The reduction of GHG emissions from 1990 to 2000 was about over 60%. Towards the mid 1990s, Lithuania's GDP began to rise and the reduction in emissions slowed down. The annual increase of GHG emissions in 2000-2006 was approximately 4% annually. In the for 2005 published report on CO_2 emissions the total CO_2 emissions for the Lithuania is equivalent to 3.9 of tonnes per resident.

Energy in the Lithuania

Consumption of oil products accounted for 30 %, gas for 28 %, nuclear power for 30 %, and other resources (solid fuel, hydropower) for 12 % of the total primary energy resources.

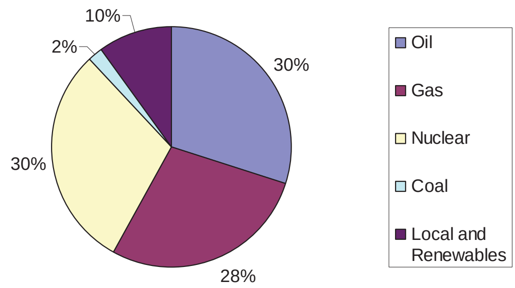

Figure IX.i - Primary energy demand by fuel type

The Ignalina Nuclear Power Plant (NPP) plays a key role in the Lithuanian energy sector, as it produces about 80% of the electricity currently produced nationally. Following the Accession Agreement to the EU, Lithuania closed the first reactor on 31st December 2004 and the second reactor shall be closed by 2010.

National electricity and gas networks have no direct connections to Western European energy systems and depend on a single supplier of natural gas from Russia. Crude oil and natural gas are mainly imported from Russia. Crude oil and other inputs to refineries constituted about 73% of 2006 energy imports and natural gas accounted for about 20% of those imports.

Lithuanian Parliament adopted new National Energy Strategy in 2007. The main objectives of the strategy are to diversify energy sources including nuclear power and to expand input of renewable energy sources. The Strategy foresees construction of the new regional nuclear power station in cooperation with other Baltic States and Poland which should start operating not later than 2015.

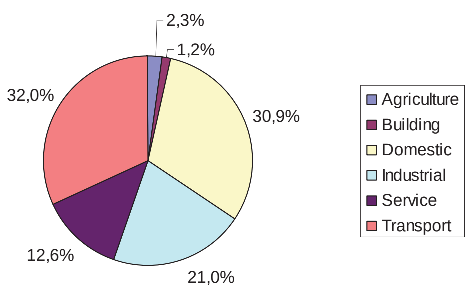

Figure IX.ii - Composition of final energy consumption to sectors of economic activity for 2005

EPBD implementation

The responsibility of the implementation of the EPBD in Lithuania is divided between the Ministry of Environment and the Ministry of Economy.

The main provisions on the energy performance of buildings and the certification of the energy performance of buildings are described in The Law Amending the Law on Construction no. X-404, adopted 17th November 2005 by the of the Seimas (Parlament) of the Lithuania Republic. The Lithuanian calculation procedure is described in Building Technical Regulation STR 2.01.09:2005, Energy Performance of Buildings; Certification of Energy Performance of Buildings, adopted on 20th December 2005 by the Order of the Ministry of Environment. The software was prepared and adopted by the Ministry of Environment. The training program, methodical material attestation, and rules and procedures for the experts were adopted by the Orders of the Ministry of Environment. The institutions responsible for the training and attestation of the experts were appointed. The Commission was constituted for the attestation of the experts. Further information on the procedure (in Lithuanian) is on *www.am.lt* and *www.spsc.lt*.

Requirements for new buildings

The energy performance class of new buildings (building part) must be not less than C. This requirement is valid for all new buildings, for which the set of the design terms (references) was issued before after the Regulation came into force. These requirements came into force on 4th January 2006. Certification requirements for new buildings came into force from 1st January 2007.

Requirements for existing buildings

The energy performance class of large buildings (building part) with a heated area of more than 1000 m² after major renovation must be not less D. This requirement is valid for all buildings after major renovation, for which the completion of the design terms was issued after the Regulation came into force. The requirements for energy performance class are not obligatory for buildings (building part) for sale or rent, but evaluation procedure will be mandatory from 1st January 2009. These requirements came into force on 4th January 2006. Certification requirements for existing and refurbished existing buildings will come into force from 1st January 2009.

Certification of buildings

Certification requirements for new buildings came into force from 1st January 2007. Certification requirements for existing and refurbished existing buildings will come into force from 1st January 2009. The first certificate of the energy performance of building was issued on 10th January 2007. The qualifications required from experts are: engineer diplomas with experience of three years in construction, special training courses and required certification practice of three buildings. Inspection of boilers fired by nonrenewable liquid or solid fuel of an effective rated output of more than 100 kW capacity will be started in 2007. Inspection of boilers fired by non-renewable liquid or solid fuel of an effective rated output of 20 kW to 100 kW and air conditioning systems of an effective rated output of more than 12 kW will start in 2008.

Relevant information

The experts training program was prepared on 21th June 2006 and adopted by the Ministry of Environment. The experts training courses started in November and the first group of 30 experts was attested on 11th December 2006. For the moment, a group of about 300 experts are being attested. The software has been prepared and adopted. The Certification Centre of Construction Products under the Ministry of Environment was appointed to manage the attestation of the experts and the registration of the certificates of the energy performance of building. Two institutions were appointed as teaching organizations for experts: Institute of Architecture and Construction of the Kaunas Technological University and Quality Management Centre of Vilnius Gedimino Technical University (32 hours of training and three certificated buildings as practical experience).

Detailed official information, texts and tools will be available on the national websites. Primary information and related legal acts are already available on the national websites www.am.lt; www.spsc.lt; www.ukmin.lt

Case study 1: Additional Insulation of Buildings

Reference: Apartment building of 5 storeys with 15 flats, built in 1988.

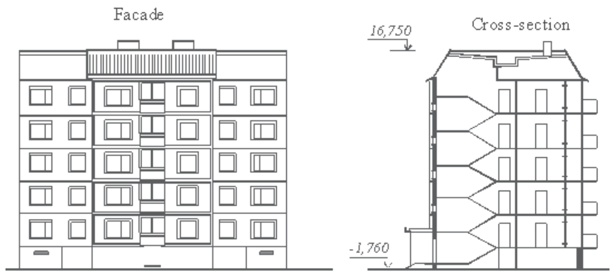

Figure IX.iii - Apartment building

Context

Addition of insulation to existing buildings is one of the most important tasks in the field of energy conservation for the Lithuanian economic policy. Thermal insulation of existing buildings at present is worse by 3-5 times than required values of the new ones. Renovation of existing buildings and additional insulation of their envelope is recognized as especially high potential in energy savings.

Building physical features

A typical apartment building of 5 storey with 15 flats, built in 1988 has been chosen for this case study. Heating is delivered by district heating. Roof of the building sloped, slated, the ceiling of 5-th floor is insulated by expanded clay grains layer of 10 cm thickness. External walls – of 3 layer concrete panes, with inside insulation of expanded polystyrene foam. Thickness of the polystyrene foam is 5 cm. The joints between the panels are with visible defects, leaky. Windows with two glass panes in the casement. Air supply vents are mounted into the window frame. Windows are leaky, glass panes installed with defective sealing in the casement.

Definition of building element	Area m^2	Heat transmission coefficient value, $W/m^2 \cdot K$	Heat losses during heating season, kWh
Windows and doors	178	2.5	46886
External walls	684	0.70	50563
Ceiling to the attic	222	1.0	23461
Floor over basement	222	2.0	46922
Total heat losses though building envelope			167832

Table IX.i - area and thermal properties of building elements. Mean temperature difference of the heating season $\Delta\theta = 20^oC$, duration of the heating season t=220 days.

External doors are wooden, also leaky, without closing devices. Basement premises unheated, with leaky joints and windows, wet. The floor over the basement of concrete panes, is without heat insulation, and has linoleum covering.

Management

The association of apartment owners is liable to provide the renovation of the certain building. The motivation of such action is based on following reasons: reduction of the expenses for the heating, improvement of indoor climate, enlargement of building market price, extension of building service life.

Performance criteria

The heat transmission coefficient value of retrofitted building element must satisfy the requirements of National Building Code STR 2.05.01:2005 "Thermal Technique of Building elements".

Definition of building element	**Required heat transmission coefficient value, W/m^2·K**	**Heat losses during heating season, kWh**
Windows and doors	1.6	30007
External walls	0.25	18058
Ceiling to the attic	0.2	4692
Floor over basement	0.3	7038
Total heat losses though building envelope		59795

Table IX.ii - Thermal properties of building elements after renovation

Decision making

The ceiling has been proposed to insulate additionally by loose fill mineral wool of 20 cm thickness. Then heat transmission coefficient value will be equal to 0.20 W/m^{2}K. The ceiling over basement has been proposed to insulate additionally by mineral wool boards from basement side. The suggested thickness of the insulation is 10 cm. Then heat transmission coefficient value will be equal to 0.30 W/m^{2}K. For insulation of the external walls the rigid mineral wool boards with thin rendering finish system have been suggested. The suggested thickness of the insulation is 10 cm. Then heat transmission coefficient value will be equal to 0.25 W/m^{2}K. All the windows are proposed to change by new ones. New windows of PVC frame with insulated glass unit are included into the proposal. One of glass panes is covered by low emission film and unit is filled by argon gas. Heat transmission coefficient then is 1.6 W/m^{2}K.

Cost analysis

Presumptions for calculation:

- mean temperature difference during heating season is $\Delta\theta$=20°C;
- the duration of the heating season is t=220 days;
- recent energy price is E=€0.1/kWh.

The total investments: €97,300.
The total sum of savings by the present value: €10,804 /years.
The simple pay-back period for the whole building is 9 years.

Improvement of the indoor climate, enlargement of building market price, possibilities to use the existing infra-structure of the city as well as the right assessment of the net pay-back period of the investments must take place at the economical analysis of the proposal.

Carbon analysis

The energy savings of near 64 % of present energy consumption will be achieved after the retrofit of the building and insulation of the building elements up to the recent requirements. The environment pollution by CO_2 gas will be decreased as well.

Key points

The final results of the renovation of the all existing building's stock (100 millions m^2 heated area) shall include the annual savings of 2.34 billions Lt, (at the recent energy price of 0.25 Lt/kWh), after the 12 years of the foreseen pay-back period.

The attraction of renovation and retrofit of the buildings only on the energy saving base is not very large and the investment profit could be proved directly with some difficulties. The promotion of the renovation must be complex, linked with the indoor climate improvement, efficiency of the building maintenance and significant enlargement of the building market price.

Case study 2: Passive Family house

Context

Family house under construction in Vilnius suburb is presented for analysis. It is experimental building with envelope elements of improved thermal characteristics. The building elements are designed to have better heat transmission coefficient than it is required according to the recent National Building Code. The constructed building will be investigated in situ with the purpose to establish the real energy consumption in it during operation. The results will be used to form further energy retention policy stages by the wider offer of buildings with high thermal characteristics.

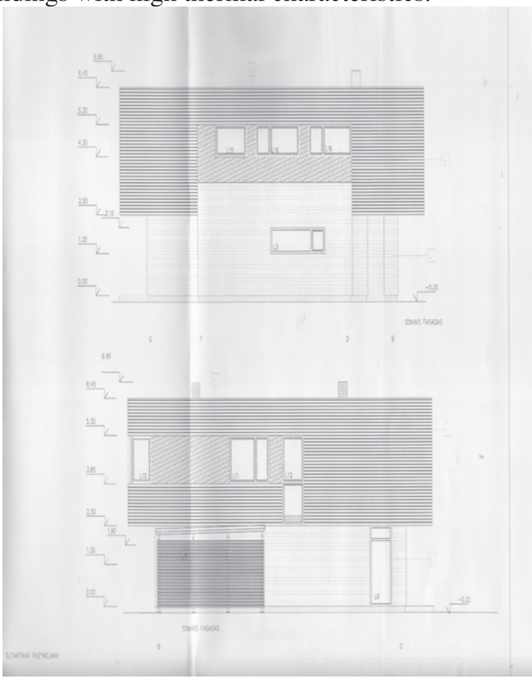

Figure IX.iv - Passive Family house

Definition of building element	**"Passive house" heat transmission coefficient value U, W/m²·K**	**Required heat transmission coefficient value U, W/m²·K**
Windows and Doors	0.8	1.6
External walls	0.108	0.20
Roofs	0.113	0.16
Floor on ground	0.113	0.25

Table IX.iii - Comparison "Passive house" and required thermal properties of building elements

The building envelope elements are designed to have better thermal insulation characteristics than required. Heat transmission coefficient value for element in a new building must comply to the ones indicated in National Building Code "Thermal Technique of Elements of Building Envelope".

Building physical features

1. New structural solutions – the new envelope elements schemes composed;
2. The air-tightness of building is warranted, hence heat losses due outdoor air infiltration is avoided;
3. Heat losses through building envelope are very low, thus conventional heating system is under question, various efficient heat recovery appliances are used for partial heating of supply air.

Definition of building element	**Area m²**	**Heat transmission coefficient value, W/m²·K**	**Heat losses assigned for 1 m² of heated area, kWh**
Windows and doors	65	0.8	26.01
External walls	273	0.108	14.77
Roof	134	0.113	7.59
Ceiling at contact with outdoor air	29	0.108	1.59
Floor on ground	134	0.113	7.59
Total heat losses, to 1 m² of building heated area (203.71 m²)			57.55

Table IX.iv - Area and thermal properties of building elements. Mean temperature difference of the heating season $\Delta\theta = 20^oC$, duration of the heating season t=220 days

Heat losses due ventilation and heat gains are not included into building heat losses calculation results.

Management

Family house is under construction at present. It is representative building with heat losses much less than in the other buildings under recent heat insulation requirements. In the neighbourhood other similar building under recent heat insulation requirements will be erected. The comparative analysis of both buildings will be provided and the result will be used as basis for the development of further requirements in thermal insulation.

Decision making

The considered building is constructed with the purpose to prove the energy retention possibilities in practice mainly in regard to family houses. The designers, construction enterprise, research institution, producers and suppliers of building products are involved into the project.

Cost analysis

The detailed analysis of investments into construction, further maintenance and operation costs of considered building and similar one under the recent requirements will be provided.

National conclusions

Lithuania signed the United Nations Convention on Climate Change (UNFCCC) as an Annex I Party in 1992 and ratified it in 1995. The Kyoto Protocol was signed in 1998 and ratified in 2002. Lithuania undertook to reduce its GHG emissions by 8% below 1990 levels during the first commitment period 2008-2012.

A rapid decrease of GHG emissions has followed the decline of the national economy in the 1990s. The reduction of GHG emissions from 1990 to 2000 was about over 60%. The annual increase of GHG emissions in 2000-2006 was approximately 4% annually. The decline in the emissions of the main greenhouse gases between 1990 and 2006 is shown in Figure IX.v.

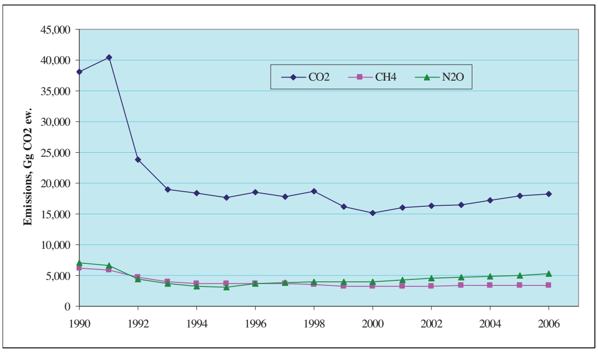

Figure IX.v - Trends of GHG emissions by gas in CO_2 equivalent, Gg

Emissions of all three gases were increasing continuously from 2000 to 2006. This increase mainly follows the growth in industrial output as reflected by the growth of GDP. Most important in Lithuania now are renovation of existing building and to expand input of renewable energy sources.

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X Malta

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National context

The Maltese Archipelago comprises the inhabited islands of Malta, Gozo and Comino, together with a few uninhabited islands, collectively termed as Malta, as a country. As one entity, Malta, after its independence from the United Kingdom in 1964, and becoming a democratic republic in 1974, joined the European Union in 2004. It is concurrently part of the Commonwealth of Nations and the United Nations. It is an independent Island-State and has had its own self-government since 1964.

Demography

According to a 2005 census [1], the Islands have a population of 404,000 inhabitants with a population density of 1,282/sq.km, making it the 6th densest country in the world [2]. It is also 11 times greater than the EU average. Unofficially it is estimated that this has risen to 420,000 as at 2007, confirming a rate of increase of 0.2% per year. Apart from a marginal increase in local population this is principally due to foreigners settling in Malta, which has increased since Malta became a member of the EU, in May 2004, today also adopting the Euro as its currency, since 1st January 2008.

Climate

The Maltese archipelago has a typical Mediterranean Marine Climate, at latitude 35°52'N, experiences high insolation exposure with a solar altitude at 79°C above the horizon in summer on 21st June and a winter low altitude sun at 31°C in winter on 21st December [3].

Solar radiation is very intense during the summer period especially since minimal cloud cover is experienced, if any. However in winter although the direct sunlight availability is reduced due to a higher cloud cover, a high amount of diffused radiation is present.

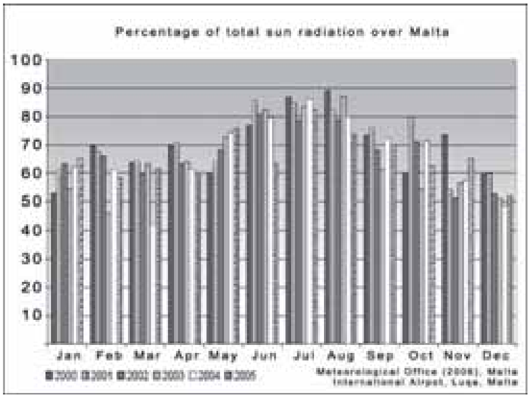

Figure X.i - Percentage of total solar radiation over Malta

Subsequently winter diffused light combined with a low altitude sun may be a persistent source of glare. On the other hand such a high number of days of sunshine, with high insolation levels, persistently flare up the potential of the sun as a renewable source of energy. Equally significant is its predominant predictable west to NW wind profile, underlying potential for a land-based or off-shore wind farm.

Energy System

Malta presently has an independent isolated energy system, relying solely on imported fossil fuels, although there are plans to connect the Islands to the European electricity grid, as well as a gas-pipeline interconnection with Libya to feed its two power stations. Coal for electricity generation used to be imported until the 1990s but this was stopped for environmental reasons. The shift and plant investment was made towards conventional oil. A biennial "State of the Environment Report" (2005), states that in 2003 over 63% of the primary energy was used for power generation. The remaining oil consumption was used for transport (85%) and only a minor share is used for other purposes (15%). Heavy fuel oil and light distillate are used for power generation. Transport fuel consists of petroleum products and a small percentage of biodiesel (0.52%) [4].

National Energy Efficiency Action Plan

With effect from 2008 and in line with EU Directive 2006/32/EC, Malta is obliged to set an energy efficiency target by 1% per year. Progress was to be reported to the European Commission by mid 2007 through an Energy Efficiency Action Plan. In February 2007 the MRA (Malta Resources Authority) published the NEEAP, Malta's National Energy Efficiency Action Plan. Among other aspects, this highlighted the importance of a dynamic energy efficiency policy, as part of a holistic energy policy. The latter has just been published (April 2009) for public consultation through MRA.

There is also a major renewable energy project to set up two large scale wind-farms, an off-shore and a land-based one, to feed into the national grid. Studies on the wind profile and ideal sites for Malta are currently under way. A political decision is to be taken on sites and investment planning by the end of this year (2009).

EPBD implementation

Transposition to Local Legislation

The EPBD was officially transposed to national law through Legal Notice 238/06, in November 2006. This formally legalized minimum EU requirements for energy performance in buildings, accompanied by a revision of the building regulations, with effect from 2nd January 2007. The salient features include insulation to flat roofs and external walls and careful positioning and design of openings, including their double-glazing depending on size of apertures, use of BAT (best available technology) for environmental control systems and insulation of domestic hot water plumbing, among others. The Maltese Building Regulations have been updated (part F: Conservation of Heat & Power) to incorporate elemental energy efficiency measures, with the aim to improving the overall energy performance of buildings. This is now in line with the requirements of Directive 2002/91/EC, better known as the EPBD, now up for revision in the form of a recast (January 2009).

National Calculation methodology & EPCs

In Malta there has been a legal revision by the new LN261/2008. This now foresees not only the design aspect of the EPBD but also encompasses a national methodology for calculation procedures to arrive at a standard form of the EPC, the Energy performance Certificate

Figure X.ii - Aerial view of Valletta and Floriana.

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The National Calculation Method for the EPBD although not yet defined by the new LN261/2008, has been launched in January 2009, after a tendering procedure for its design. Locally it is termed as the EPRDM (Energy Performance Rating for Dwellings in Malta). Training courses to architects & engineers are being conducted on a quarterly basis commencing spring 2009. The lodging of the EPC and its management will be run by the MRA.

Financial Incentives in RES in buildings

In November 2008 the Maltese government launched a financial incentive scheme whereby both new and established home owners (and commercial entities) can apply for subsidies for installing solar water heaters and photovoltaic panels on rooftops, in line with standard policies set out by the MRA. Such subsidies can amount to 50% rebate on purchased products. Such a scheme, combined with a market increase in electricity tariffs has already seen a notable shift in consumption patterns as well as a surge in the RES market in Malta. This further reduces the country's carbon footprint for the Islands. The MRRAE (Ministry for Resources & Rural Affairs) has launched its own Carbon Footprint guidelines [http://mrra.gov.mt/downloads.asp#videos].

City Scale Policies: Valletta

Valletta is Malta's Capital City. It is in essence a historic yet modern city, cordoned with lines of fortifications, dating back to the 16th century, as built by the Knights of the Order of St. John, under the patronage of Grand Master Jean de La Vallette, hence its name. Although listed as a UNESCO world heritage site, it is today a living modern city bustling with commercial activity, a must-go-to for tourists. Most residents have moved out, in preference of sub-urban homes, or living on the satellite equally old town of Floriana.

With the goal towards cutting back carbon emissions stemming from transport in the Capital, the Maltese government embarked on a number of initiatives. One of the most popular ones is the "park and ride" scheme, where commuters park their car outside Floriana, in a ditch between fortification lines, taking a free shuttle minibus service into Valletta. Similarly a ferry service runs between Valletta and Sliema, a popular coastal tourist resort. Residents use this to come to work in the City while tourists use it to visit Sliema and its environs. Both services are complimented with inner city transport by means of electric vehicles. Furthermore indefinite ditch-screened parking is encouraged at a nominal cost (parker tip), as opposed to a time-based parking scheme to enter VLT, discouraging regular visitors from occupying parking bays for a whole day. This encourages parking space rotation, making Valletta more attractive for commercial entities albeit with a marginal increase in carbon emissions.

Sub-Urban Policies & Case Study

The Housing Authority in Malta oversees the allocation for low and middle class social housing (subsidized rental and outright sale). It has recently embarked on a new low-carbon policy for newly built apartments, essentially through passive and active measures for new designs and already built large scale housing developments. Apart from the standard default measures introduced, apartment owners were also encouraged to install their own tailor-designed green energy efficient measures to cut back on carbon emissions. Support was also offered through a technical team of experts through regular monitoring of individual apartments. This helped to draw up a case by case model energy profile of each diverse household. A pilot study was initially set up for this purpose, specifically with such an implementation in mind, inclusive of follow-up monitoring. Other similar projects today follow suit.

Birkirkara Housing Project

One pilot study encompassing all such measures was completed in 2005, on the outskirts of Birkirkara, Malta's largest established predominantly residential town. This development lies on a corner site with a north-south axis comprising 11dwelling units and a showroom; the development overlooks a major arterial road, the Birkirkara by-pass around the town.

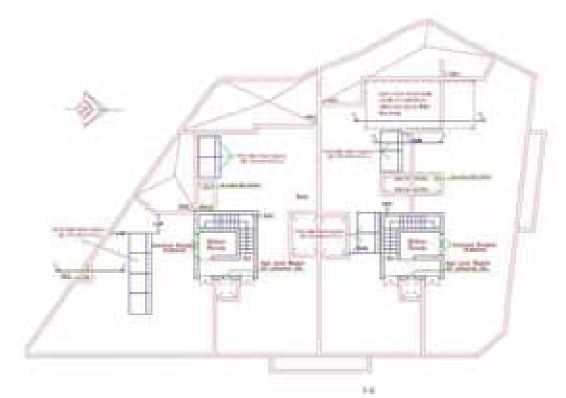

Figure X.iii - Birkirkirkara, Tal-Ftieh, Malta – Roof plan

Measures introduced, later deemed as default:

- Tinted double glazed windows and doors.
- Louvered protective elements over external windows and doors throughout.
- Expanded polystyrene insulation over the flat reinforced concrete slab roof, protected with crushed limestone and a concrete screed.
- Whitewash applied to roof screed for reflectance.
- Expanded polystyrene, 75mm cavity insulation to all external double walls (facing S and SW).
- Increased building height to the whole top floor from 2.97 to 3.54m.
- Solar Water Heaters for all apartments, with 24x7 monitoring display.
- Photovoltaic 1.5 kW peak, grid connected system, with 24x7 monitoring display.
- "Sun-pipes" delivering the abundant natural light to the garages' common areas at basement level.

The development incorporates both passive and active solar measures. From early monitoring and occupants feedback, the most effective salient passive features were found to be the stack ventilation, louvered elements and insulation, while conspicuous active measures were the SHW, PV and the sun pipes lighting the basement garages.

Figure X.iv - Birkirkirkara, Tal-Ftieh, Malta – Social housing

Through monitoring of two annual cycles, based on average power station efficiency at the two power stations in Malta, standing at 0.867kgCO_2/kWh, the development was found to have the following annual lower carbon and energy savings:

- Tinted D-G elements: 7,000 kWh (6 tons CO_2)
- White painted roofs: 4,500 kWh (4 tons CO_2)
- EPS roof insulation:11,000 kWh (10 tons CO_2)
- EPS insulation to walls: 4,700 kWh (4 tons CO_2)
- Solar Water Heating: 10,000 kWh (9 tons CO_2)
- Photovoltaic System: 1,314 kWh (1.2 tons CO_2)
- Sun pipes: 800-1,200 kWh (0.7-1.0 tons CO_2)
- TOTAL SAVINGS: 40,000 kWh (35 tons CO_2)

Three years after the project (2005) such energy saving benefits have become benchmarks for other Housing Authority projects, today these are even being picked up by private developers of apartment blocks in various parts of the Islands [5].

Figure X.v - SWH uptake throughout – Pembroke Social housing

Further to the above mentioned sub-urban pilot project through the Housing Authority, and its spread in the domestic sector, various single non-domestic buildings were identified as representative urban case studies which demonstrated similar energy efficient measures, namely incorporating both passive and active measures. From a handful of examples, the following three case studies were deemed to be the most representative. These are all typical office buildings, associated with financial institutions, namely two leading banks and the stick exchange in Malta.

Case study 1: Malta Stock Exchange, Castille Square, Valletta, Malta

The Malta Stock Exchange is housed in a refurbished 19th century building in Valletta. This was better known as the British Garrison Chapel, considered as one of the earlier abandoned buildings in a UNESCO World heritage site. With the Government as the principal client, the broad brief was to have a heritage sensitive yet energy efficient refurbished edifice. The design architects, AP (Malta) & Brian Ford & Associates (UK) approached the project with a vision of a less intrusive yet energy efficient intervention. This approach saw the dilapidated inside being gutted out to be replaced by an independent timber and steel structure supporting cellular offices on the wings overlooking an internal courtyard and circulation space, also incorporating open offices where much of the day-to-day activity takes place [6].

Figure X.vi - Malta Stock Exchange, formerly the British Garrison Chapel, Castille Square, Valletta

For a Mediterranean Island where cooling is of a greater concern than heating, a non-typical ingeniously designed cooling system, uses nebulised spray particles injected into the air, losing their latent heat causing the cooler air to sink into the central aisle of the building, displacing any warm air up and out to the sides of the building. This new technology is known as passive downdraught evaporative cooling (PDEC), today also broadly labeled as PHDC, since experience has shown that a hybrid system performs better than a solo passive one.

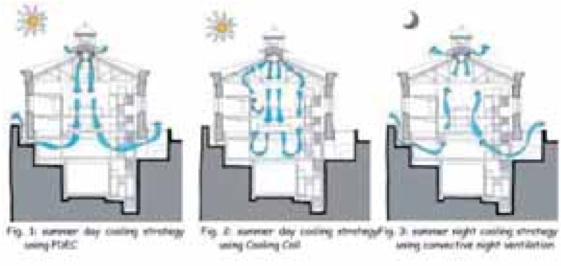

Figure X.vii - Malta Stock Exchange, PDEC system

With the southerly winds, RH values tend to rise above 65%. In this instance cooling coils along the ridge come into action, cooling the entrained summer air. During night time the system is reversed by opening lower vents to allow cooler air to enter from the shaded surrounding Barrakka gardens, thus pushing out any warm air that may have accumulated in the preceding day time hours. Although the smaller cellular offices still rely on state of the art air conditioning, the central atrium, with open plan offices is rendered usable through the warm spring and summer months.

Figure X.viii - Malta Stock Exchange, Courtyard lighting from Zenith light and Shading device for lateral solar control

Other innovative features are the zenith natural lighting and the external louvered elements adapted as shading devises when opened out on vertical rails. The building site has a floor area of 1,271m^2. After some minor adjustments of the system through lessons learnt, being a first for Malta, this major refurbishment was completed between 1998-2001, and is today in full operational mode [7].

From preliminary post-occupancy monitoring, as reported by WSP Environmental Ltd. [8], the potential savings for the atrium space alone represent over 60% of the predicted energy consumption for large fan coils units. The general building improvements (shading, insulation, night ventilation) also benefit the cellular office accommodation, reducing the energy consumption of the cassette units by approximately 23%. The total cooling energy consumption for the whole building using fan coils was estimated at approximately 103,924 kWh, compared with 54,139 kWh for the built solution using cooling coils and PDEC, resulting in a total energy saving of 48%. This represents an annual saving of €3,597/year based on €0.07/kWh. The economic benefits are capital and running cost savings and the environmental benefits are reduction in CO_2 emissions by approximately 28,152 kg CO_2 per year.

Case study 2: BOV - Bank of Valletta Head Office, Sta Venera, Malta

Figure X.ix - BOV Head Offices, Interior Street

In conformity with leading international banking practices, and living up to its name after the fortified Capital, the new Bank of Valletta Computer Centre and Head Office is now complete and operational in the form of a fortified stronghold of precious customers' data, together with its administrative headquarters and international links, all coming together under one roof, one nucleus hub in a new building occupying the corner site of the former "Canada Dry" beverage factory.

In consideration of its prominent site and eye-catching "cavalier" approach, the new building is considered an ethos statement in contemporary energy conscious architecture, complemented by an equally evocative civil engineering feat. In an attempt towards understanding the innovative design aspects and building technology of the day, the different intrinsic features of the building are to be applauded, here highlighted graphically.

The external walls consist of two globigerina limestone skins, linked by precast concrete bond stones. These were exploited to produce an architectural articulation of the façade. The bond stones are in fact located at every fifth course, and are linked to precast concrete elements that merge also into lintels, as well as into specially weathered, and drained, window sills. The precast elements are composed of white concrete, with a waterproofing admixture to inhibit moisture migration and cold bridging.

Figure X.x - Large windows for natural light requiring efficient external vertical & horizontal shading device

Internal street is whitewashed, abundant natural (north) light exploits the Mediterranean sun. Sloped steel arched roof structure faces north, eliminating direct solar gains in summer, while orientation was carefully chosen to maximise overhead sun in winter. All openings are double glazed, argon filled with a UV absorbent coating. Thermal mass plays an important role in external walls, composed of an external skin of 180mm, 75mm cavity and an internal skin of 230mm hollow core blockwork, rendered to a smooth finish (Figure X.xi).

Although the walls are not insulated the cavity serves its purpose well enough as a thermal and moisture barrier. Roofs are insulated employing EPS, protected with a concrete screed laid to falls.

Figure X.xi - Globigerina limestone contributes to thermal mass

Figure X.xii - BOV Head Offices, Exterior View

Perhaps one of the more striking design features of this building is its internal street. This gives it its introvert well controlled microclimate and a dynamic interior through its line of steel columns, clad in precast terrazzo cladding shells (recycled marble), which are used as permanent formwork for the concrete encasing. This idea allowed the architects to select the colour scheme of the terrazzo to match the interior design. It also produced a smooth cladding around the columns, rather than the typical multi-faceted polygon surface. This therefore reduced the embodied energy of the columns.

The glazed canopy over the internal street is laid on a diagonal rib and mullion system so that the glass panes are diamond-shaped, all lie in a shallow barrel vault form. The glass used in the canopy is double glazed with a self-cleaning layer, so that no external cleaning gantry is required. It also has a low emissivity coating layer, in order to reduce UV transmission to about 1%, and thermal energy transmittance is reduced to 35% of incident solar radiation. External apertures are double-glazed everywhere.

The structural system is quite particular, although it cannot be claimed to be a first for Malta, yet it is still ingeniously laid out: It is based on a composite steel and concrete frame construction. The grid pattern is based on a 7.8m x 7.8m square grid, which is used in the lower three levels to optimize car-parking bays. The grid is then rotated by 45^o, using the same column positions, to obtain the more open office layouts, and the internal street, in the upper levels.

The lower three levels are laid out on in-situ concrete columns; beams are in precast pre-stressed concrete, carrying "*predalles*" and in-situ concrete topping. In the upper levels, columns are steel, encased in concrete for fire and corrosion protection. Beams are steel H-sections, carrying the "*predalles*" and in-situ topping, resting on the lower flange, such that the whole steel section is embedded in concrete. A flush structural soffit is thus achieved, without any additional fire-proofing required. Diagonal spans of about 11m are used in the upper levels.

Innovation also stands out through other practical architectural design features. These include the projecting vertical stone flaps, to protect west-facing windows, and to screen views of the unattractive adjacent site; the use of curved glass block is there to obtain a similar visual screening but not at the price of reducing natural light in the corridor areas.

Other features include the arrangement of steel bridges and main staircases in the internal street, the integration of smoke extraction louvers with the main façade windows and the use of louvers on two office façades to control incident sun and glare. The floor tiling pattern is based on a granite and porcelain ceramic layout, carefully designed in order to intentionally reflect the bank's corporate colours in a subtle way. A particular glazed concertina screen in the internal street, a completely structural glass entrance with glass mullions, and glass enclosed staircases complete the almost monochrome internal street design. However, bright colours were also used to animate the street level of this space, in contrast to the starker external treatment, a concept originating from the idea of a jewel inside a more restrained box.

In Malta, where annual rainfall barely exceeds 450mm, water production has a high energy value, estimated at $5.72kWh/m^3$ of potable water [9]. (This varies seasonally and annually as WSC, the local water utility, is continuously striving to improve its efficiency through optimum membrane management). In the absence of a second class water system in the country, most dwellings still use mains water as flushing water for bathrooms.

With this in mind, and BOV's aim to reduce mains water consumption, all rainwater is collected in four large reservoirs which together hold a total of capacity of $1,650m^3$ of water. From these 1.65million litres of water, 500,000L are kept as a separate reserve to be used in case of fire. The remaining 1150,00L are used as second class water, pumped up to the roof tanks, supplying flushing cisterns in all the Centre's toilets. These are claimed to serve the purpose well enough.

Compared to the former Computer Centre and Head Offices in Sliema, the new BOV centre's facility manager claims that overall, after monitoring similar periods in 2005 and 2006, given that similar thermal comfort conditions were set, a comparative energy demand saw $2.61kWh/m^2$ being used at the former Sliema Centre, whereas only $1.10kWh/m^2$ were used for the new Sta. Venera Operations Centre. This means an energy saving of $1.51kWh/m^2$ which translates into $1.31kgCO_2/m^2a$. Given the building has a total floor area of circa $24,400m^2$, over four floors, the annual carbon saving is estimated at 32 tons of CO_2 annually.

The architectural and structural engineering design was by TBA Periti, the Project Management by Quality Project Management Ltd, and the mechanical and electrical engineering by Engineering Services.

Case study 3: HSBC Bank, Operations Centre, Qormi, Malta

Following the take-over of Mid-Med Bank Malta, by HSBC International, through Midland Bank, of UK in 1999 [10], all local branches were re-planned and refurbished in line with corporate colour schemes and the "*modus operandi*" of HSBC; there was also a gradually increasing effort towards overall energy efficiency, albeit even if only as an economically sustainable measure. Today such an approach has moved more towards environmental and social goals, where even though HSBC is one of the local leading giants in banking practices, it is still striving to reduce the Bank's carbon footprint in Malta.

Apart from revamping a number of local branches, in every town in Malta and Gozo, and setting up an international call centre, HSBC has refurbished its Operations Centre in Qormi; this is essentially an extension of the former Mid-Med computer centre, entailing a major overhaul in design and re-planning.

This was an opportunity too good to be missed for adopting energy efficient measures, aiming towards a cost-effective running of the building and a holistic more sustainable development.

Figure X.xiii - HSBC Operations Centre, Exterior View

Distinct and untypical of the standard glazed office building, the salient passive low energy design features include:

- Small openings facing south & west;
- Thermal mass composed of solid masonry;
- Heavily shaded main entrance (facing west), with horizontal canopy and evergreen trees;
- Glazed staircase linking all floors to the spacious voluminous foyer;
- Low emissivity coating to double glazing, throughout the building;
- High floor to ceiling heights in most open plan offices, allowing for greater air temperature stratification;
- Building fabric temperature retention was reduced by means of a mechanical ventilation system independent of the state of the art efficient A/C (air conditioning) system;

Figure X.xiv - HSBC Operations Centre, solid walls, small openings facing a setting sun

Other environmental control features resulting in a low carbon building include:

- Replacing conventional A/C units by 30% more efficient inverter-driven units (over 70% of their offices now run on these new systems);
- The ozone-depleting R22 was phased out, to be replaced by R407C refrigerant, to be eventually replaced again, only five years later with the latest second generation R410A refrigerant (this saw an improved performance of 14.5%);
- Energy-recovery ventilators were installed reducing electrical energy loads on A/C systems by an average 20-30%;
- Fluorescent lighting systems were fitted with electronic ballast plus tubes replaced with the latest slim T5 units, meaning 31% improved efficiency, 50% lifespan increase (& 38% less glass and phosphorous);
- A central BMS was introduced, linking close to 50% of offices and branch premises, permitting central control of A/C temperatures and automatic switching and interface of A/Cs, ventilation, electric water heaters and lighting levels;
- New electric lifts were installed, having a more efficient use of space as these need no machine room, with a 3:1 energy improvement over conventional hydraulic type lifts;
- Power factor correction units were installed, inclusive of most offices, cutting down on inherent electrical installation losses;
- Following a decision to switch form electric water heaters to SWH, in 2007, highly efficient vacated tube solar water heaters were chosen instead of the conventional thermo siphon units. These are used extensively at the staff gymnasium at the Operations Centre.

Finally facility managers at HSBC today claim that over the last two years the bank has reduced energy use by more than 350,000 kWh when compared to 2007. This saving equates to a reduction of over 300 tonnes of CO_2 emissions over two years.

Figure X.xv - HSBC Operations Centre - staff gymnasium: highly efficient vacated tube solar water heaters used (instead of conventional thermo siphon units).

Although no floor plans or other drawings were forthcoming, claiming security reasons, layout can be described as a self-contained compact plan (no internal or rear courtyard), with its main vertical circulation through the reception lobby via stairwell and lifts. A separate small outbuilding accommodates a business centre receiving corporate and other upmarket clients.

The building's design was by HLN Architects, Cardiff, (UK), in collaboration with Bezzina & Cole Architects (Malta).

Planning Legislation

The Malta Environment & Planning Authority, locally known as MEPA, was a development from a former PA, the Planning Authority, originally set up by a Planning Act in 1992, repealing a former PAPB (Planning Area Permit Board), overseeing building development across the Maltese Islands. The recast into the MEPA occurred in 1997, merging the PA with the former EPU (Environment Protection Unit), stemming from the onset of environmental issues being raised ever higher on Maltese and International Government agendas. Over the last ten years both revised "Local Plans" for development and general "Planning Policies" have focused evermore on the protection of the environment, particularly becoming more sensitive to land use and type of development. In view of the lack of available space to build, and with the increase in population, there are now moves to promote re-use and refurbishment of old buildings in village cores and town centres. This is also stimulating the property market which would otherwise be in dire straits.

Today the MEPA is the only fully autonomous Authority overseeing all master planning development procedures for the Maltese islands, unlike what happens in most EU countries, with regional development and local municipalities overseeing such local development. In view of its mammoth task and ever-increasing public complaints of its delayed processes, it is now lined up for a major review and reform (July 2009), now falling within the Prime Minister's portfolio.

Today, MEPA processes over 8,000 applications for development permissions annually. Plans, documents and correspondence with various stakeholders are processed for each application through its three Boards. A new "*eApplications*" on-line system brings together different platforms and technologies into one homogeneous system which allows clients to view application details, submit and pay for applications online and send/receive correspondence digitally thus increasing participation, efficiency and transparency, also reducing MEA's own carbon footprint. Internal case processing and all internally generated documents are digitally recorded within the system. A role-based security system allows users with various rights to interact with the system in a secure web-based environment.

National Conclusions

> *"Government will encourage and facilitate the achievement of increased energy efficiency in electricity generation and distribution, and in end-energy use, and will lead by example"*.
>
> *- A proposal for an Energy Policy for Malta, MRA, June 2006.*

In essence this is one key objective of Malta's Energy Policy, which went through public consultation to completion in September 2006. Although still considered a first draft proposal it is nevertheless considered a formidable national policy document. Its policy areas hinge on the three pillars of EU energy policy guidelines, namely security of supply, a level playing field for an open energy market and the protection of the environment [11].

A prelude "Framework Document" to the draft energy policy (1999) [12], highlighted the need for capacity building, prompting the need for a breakaway from the state-controlled (corporation) utility, Enemalta. This eventually led to the setting up of an energy regulator in 2000, the MRA (Malta Resources Authority).

Energy efficiency is a key objective in the Maltese Government's energy policy. It can have a significant impact on the demand for energy, and so can reduce the country's fuel bill and the release of carbon into the environment. In this light and in line with EU requirements, the Government has prepared a NEEAP (National Energy Efficiency Action Plan) in October 2007, involving all local stakeholders. The scope of this action plan is savings in energy end use in line with Directive 2006/32/EC.

It is widely perceived that the potential for improving energy efficiency exists. This energy efficiency plan is designed such that the part of the technical potential that yields the most savings for a given investment is identified and given first priority for exploitation. The general objectives of this National Energy Efficiency Action Plan are to identify cost-effective measures that will generate energy efficiency and to chart a plan whereby these measures are implemented in a structured holistic manner, in line with the following strategy:

- Ensure that the public sector becomes a role model in energy efficiency;
- Promote increased awareness and behavioural change by consumers on an individual level;
- Adopt financing tools and economic incentives targeting all sectors, implemented in full compliance with the applicable State aid rules, that will stimulate take up of more efficient technologies;
- Take advantage of, and support, international efforts – in particular at EU level – to ensure that more efficient energy using products become available to the consumer;
- Use legislation and fiscal instruments judiciously, for example by setting standards for energy performance in buildings or for providers of energy services such as auditors or installers;
- Carry out research in energy efficient technologies and practices suitable for adoption in Malta; and
- Create the organisational structures necessary to support the achievement of these objectives.

These measures are currently being implemented gradually under the respective entities concerned.

At EU level, the current strategy is to ensure the development of market-based instruments so as to promote energy efficiency. There are limitations to what such instruments may attain and the mode of their implementation in a small economy such as Malta, due to the small size of the market.

Energy efficiency is perhaps the best most basic measure towards cutting back CO_2 emissions, even before resorting to Renewable Sources of Energy. Although an unspoken fact, the bare truth is that very few countries are willing to trade off their economic growth and social well-being to flag a fully green lifestyle. The right balance needs to be struck between economic growth, social well-being and environmental protection, the three pillars of sustainability.

Directive 2006/32/EC of the European Parliament and of the Council of the 5th April 2006 on energy end-use efficiency and energy services sets the targets for energy efficiency achievements in energy end use for each Member State with a cumulative target of at least 1% of inland energy consumption for each year reaching a total 9% reduction within 9 years. The idea is to improve energy efficiency in all end-use sectors, with a view to solving environmental, self-sufficiency and cost problems while adequately providing for increasing needs for lighting, heating, cooling and motive power without major upheavals. This is especially true when seen in the light of the Kyoto Agreement to reduce carbon dioxide emissions, where improved energy efficiency will play a key role in meeting the EU Kyoto target in an economic way.

In addition to MRA's Energy Policy and the NEEAP, the National Commission for Sustainable Development (NCSD) was established by the Environment Protection Act (Cap 435 of the Laws of Malta). Its functions are established in the same act. These include identification of relevant processes or policies which may be undermining sustainable development and propose alternative processes or policies to the Government for adoption and preparation of a National Strategy for Sustainable Development.

The NCSD has since 2002 been involved in proposing and drafting a National Strategy for Sustainable Development [13]. The process leading to its development included extensive public consultation and the involvement of government ministries, departments and public sector agencies. The Strategy has been adopted by the Commission for submission to the Cabinet of Ministers in 2006, later endorsed by the Government of Malta.

The sustainable development strategy proposes 20 priority areas for Malta. These areas were given major importance during the consultation process and the NCSD considered them as warranting foremost attention for the attainment of sustainable development goals in Malta. Of particular and direct relevance are the priority areas of tourism, transport and buildings among others, as these warrant most attention in order to reduce carbon emissions.

At EU level, members of the European Parliament on a specially appointed Energy Committee recently backed proposals that should see all buildings constructed in Europe after 2018 having to produce their own energy. The plans relate to proposed changes to the Energy Performance of Buildings Directive. MEPs on the committee want VAT reductions to be available for materials related to building performance, particularly thermal insulation. They also want an Energy Efficiency Fund set up to support private and public investment in buildings. Increasing people's awareness of how to save energy and tips on energy saving is also proposed to be available on a common website. The Maltese Government is working along these lines with such proposals being implemented through various sectorial policies.

Most emerging European member states also want solar panels and heat pumps to be used to ensure that buildings can produce their own energy. They also want national targets to be set up and that the European Commission establishes a Europe-wide definition of "zero energy buildings". (The UK is already showing leadership in this area, making headway through its Code for Sustainable Homes).

The Energy Committee also wants the European Commission to establish a common methodology for calculating the energy performance of buildings. The recast of the EPBD augurs well in this direction, as it proposes major changes in cost-optimization for energy efficiency measures among other aspects. In Malta, the standing EPBD directive is being implemented through a legal notice while the setting up of a national calculation methodology is still in its infant stage, with energy assessors still being trained with a view towards energy certificates for dwellings due to be initiated from 1st June 2009.

Transport remains an outstanding area that requires much more than energy efficiency in fuel type and technology. Government has already recognized the need to set up a transport policy, along the lines of increasing options for modes of transport. The public bus service is about the only public transport system available in Malta. As a consequence private car ownership is ever-increasing, including quality cheap second hand car imports. Although the "park and ride" system is in place for Valletta and Floriana, a national decentralized bus transport network is being planned.

For Malta, apart from energy efficiency, the main options for renewable energy are wind, solar thermal and solar photovoltaic systems, with wind being the most likely to be implemented in the imminent future. Government has also introduced support mechanisms in its efforts to increase renewables in accordance with standing EU Directives. Grants are provided to reduce the investment cost for renewable technologies, including electric vehicles, solar photovoltaic system, wind turbines, and solar water heaters. Together with buildings' energy efficiency, these go a long way towards low carbon emission in the built environment.

Feeling the wrist pulse of the human body for a minute is perhaps one indicator of its health. Equally COST action, C23, running for four years, has literally felt the pulse of progress in energy efficiency. Malta's situation is reported here through its contribution to the Euro-Carbon Atlas. It maps the country's past efforts, present policies and future strategies towards lower carbon emissions.

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HLN Architects, Cardiff, UK.
HSBC Malta Ltd., Qormi, Malta.
Housing Authority, Ministry for Social Policy, Malta.
MRA – Malta Resources Authority, Ministry for Resources & Rural Affairs, Malta.
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XI Netherlands

Mr René Wansdronk, Wansdronk Architecture

National context

General

The Netherlands consists of 12 provinces (provincies, singular - provincie); Drenthe, Flevoland, Friesland (Fryslan), Gelderland, Groningen, Limburg, Noord-Brabant (North Brabant), Noord-Holland (North Holland), Overijssel, Utrecht, Zeeland (Zealand), Zuid-Holland (South Holland). The monarchy is hereditary; following Second Chamber elections, the leader of the majority party or leader of a majority coalition is usually appointed prime minister by the monarch; deputy prime ministers are appointed by the monarch. The legal system is based on a civil law system incorporating French penal theory. The law, regulating the construction of buildings in all 12 provinces, is the Dutch Construction Standard (in Dutch Bouwbesluit).

Climate

The climate is temperate and marine, with cool summers and mild winters. The temperature varies between 0°C and 25°C, and seldom drops below –10°C or rises above 35°C.

Demographics

The Netherlands is located in Western Europe between Belgium and Germany, at the mouths of three major European rivers (Rhine, Maas or Meuse, and Schelde), and bordering the North Sea. The total area is 41,526 km^2, with 33,883 km^{2}land area and 7,643 km^2 water area. The terrain is mostly coastal lowland and reclaimed land (polders); and some hills in the southeast. The coastline has a length of 451 km. The lowest point is -7 m, located in the Zuidplaspolder, and the highest point is 322 m, located at Vaalserberg. The urban population has a share of 82% (2008) in the total population of 16,715,999 (July 2009 est.).

Carbon dioxide emissions

In 2007, GHG emissions in the Netherlands were reduced to the third consecutive year. The total emissions volume amounted to 205 billion kg of CO_2 equivalents, i.e. 4% below the level of 1990, the base year of the Kyoto protocol. This is borne out by calculations conducted by Statistics Netherlands (in Dutch CBS) and Netherlands Environmental Assessment Agency (in Dutch RIVM).

Energy in the Netherlands

The natural resources are natural gas, petroleum, and peat. The electricity production is 105.2 billion kWh (2007), the consumption is 122.8 billion kWh (2007), the exports are 5.48 billion kWh (2007), and the imports are 23.09 billion kWh (2007). The oil production is 88,950 bbl/day (2007 est.), the consumption is 984,200 bbl/day (2007 est.), the exports are 1.639 million bbl/day (2005), and the imports are 2.648 million bbl/day (2005). The oil proved reserves are 100 million bbl (1st January 2008 est.). The natural gas production is 76.33 billion cu m (2007 est.), the consumption is 46.42 billion cu m (2007 est.), the exports are 55.66 billion cu m (2007 est.), and the imports are 25.73 billion cu m (2007 est.). The natural gas proved reserves are 1.416 trillion cu m (1st January 2008 est.).

The share of renewable energy in the final energy consumption in 2006, and the target for 2020, is 10 and 20% for the EU-27, 40 and 50 percent for Sweden as the highest level, and 3 and 14 percent for the Netherlands. The extra costs in 2020 for sustainable energy in the Netherlands, depending on the oil and CO_2 price levels, are estimated on € 1 to 2 billion per year (CE Delft).

Information

CIA World Factbook

Building regulations

The Netherlands has the following set of building regulations relevant to the implementation of EPBD.

The EPG (in Dutch Energie Prestatie Gebouwen, EPG) will be the national code for new and existing buildings from 1st January 2011 onwards, and will be based on CO_2 emission. The EPG will be implemented at the end of 2009, and will be added to the Dutch Construction Standard (in Dutch Bouwbesluit) in January 2011. The new Dutch Energy Performance Buildings code NEN 7120 will follow the thirty European standards, which are developed within EPBD.

EPBD implementation

Calculation method

Energy Performance Buildings (EPG)

The EPG (in Dutch Energie Prestatie Gebouwen, EPG) will be the national code for new and existing buildings from 1st January 2011 onwards, and will be based on CO_2 emission. The EPG draft or green version is published February 2009, the EPG comments deadline is May 2009, and the EPG final version is available in September 2009.

The EPG will be implemented at the end of 2009, and will be added to the Dutch Construction Standard (in Dutch Bouwbesluit) in January 2011. The new Dutch Energy Performance Buildings code NEN 7120 will follow the thirty European standards, which are developed within EPBD, to calculate the EPC, which will reduce to 0.6. The EPG will integrate the Dutch EPA for existing buildings, with the Dutch EPN for new buildings.

Energy performance requirements

Energy Performance Standard (EPN)

The EPN sets requirements for the energy efficiency of new buildings and major renovations of existing buildings since 1995. The builders can choose their own package of measures to meet the requirements. The today minimum value of the Energy Performance Coefficient (EPC) is 0.8 for residential buildings. For non-residential buildings the value differs per category.

Energy performance certificates

Energy Performance Advice (EPA)

The EPA quality assurance system and the EPA calculation procedures have been ready since December 2006. For this calculation method for existing buildings no requirements are set. In the Regulation of Energy Performance (REG) issued on 29th December 2006 the Energy Performance Certificate requirements are outlined. The classes run from A (very energy efficient) to G (very energy in-efficient).

Energy Index (EI): The EI indicates the standardized energy use per m^2 net floor surface in MJ/m^2.

Energy Performance on Location (EPL): The EPL is used for larger scale projects such as city areas, and can not be applied for buildings.

Optimal Energy Infrastructure (OEI): Finally the OEI could replace the EI, the EPA, the EPN and the EPL, as a univical building code.

Inspection of systems

Inspection of boilers and air conditioning

I. Inspections of boilers – Article 8

The system that the Netherlands has implemented will lead, with regard to the inspection issues as described in the directive, to the intended result on the basis of both a voluntary scheme and legislation. This system consists of 3 main paths.

1. Domestic buildings with an individual boiler
In the Netherlands small boilers are checked and maintained every year or every two years, depending on the type of the boiler. To stimulate the replacement of older boilers by a new energy efficient condensing boiler, a tool has been developed for consumers: “de Verwarmingswijzer”. The tools give consumers insight, based on the current installation and the current gas use, if a new energy efficient heating system is economically viable.

For more information please go to *www.verwarmingswijzer.nl* (information only available in Dutch).

2. Boilers larger than 100 kW
For large boilers (>100 kW) the Netherlands complies with current legislation in the Environmental Law. This means a mandatory regular inspection of the boiler according to a specified scheme.

3. Inspection based advice on the heating system
For non domestic buildings and domestic buildings with a collective boiler a tool has been developed to advice the owner and/or user of the building on possible measures to make the installation more energy efficient. With this tool, the Installatie Performance Scan, the installer or consultant scans the existing installation of the building, heating as well as cooling, on energy efficiency. The tool is unique because it provides an integral check on the generation, controls,

distribution etc. Altering the installations on the basis of the scan can lead to energy use reduction and reduction on the chance of breakdown of the installation and higher comfort levels in the building.

For more information please go to *www.installatieperformancescan.nl* (information only available in Dutch).

II. Inspection of air conditioning systems

Article 9 on the inspection of air conditioning systems is fully implemented. However the inspection of air conditioning systems is dispersed amongst different parts of national law. Therefore, an improvement will be made to aggregate the inspection of air conditioning systems completely to environmental law. The inspection of the air conditioning system will be coordinated with the inspection on behalf of the CFC-regulation. This will come into force at the end of 2008.

Information

Inspection of systems, information source: Ministry of Environment (VROM), Implementation of the EPBD in the Netherlands: Status and planning in June 2008

Other initiatives

DBGC indicator BREEAM-NL

Stichting Bouw Research (SBR), or Foundation Construction Research, is housing and managing the Dutch Green Building Council (DGBC). The DGBC is developing a Green Building Certificate which is based on BREEAM. The project development members need an international indicator. BREEAM (UK) is the first and oldest indicator, and is selected to be the DGBC indicator. BREEAM-NL will be the translation to Dutch conditions. Today existing Dutch labels, standards and indicators such as Energielabel, EPC norm, GreenCalc, GPR-Gebouw, and Eco-Quantum, and the USA label LEED will be integrated.

EPG and EPA-NR

The inspection protocol and the calculation methodology as an outcome of the European project Energy Performance Assessment for existing Non-Residential buildings (EPA-NR) is partly used to develop the EPG.

Figure XI.i - Artist Impression solar house type A © Franke Architekten

Case study 1: Sliedrecht, The Netherlands

The project

This is a solar housing project based on passive house technology. Twelve solar houses in three types (A, D en E) have been built against the inner slope of a river dike in Sliedrecht, the Netherlands, (20 km east of Rotterdam). This row of single-family houses was realized for the local housing market, as part of a small project consisting of 23 houses (12 solar houses and 11 conventional, traditional houses) and 1 small additional office space. The 12 solar houses were built on the principals of passive house technology and were developed by the architect himself. He created, especially for this reason, a company called Archidome Holland BV.

Objectives

One of the main objectives of this solar project was to prove that solar houses, designed and based on passive house technology, can compete in the housing market in Holland on price, quality and comfort - especially if the owners of the houses understand the purpose and the quality of the technology involved. In this way prospective buyers will start to recognize the additional value in sustainability, comfort and quality.

These houses are – as compared to Dutch traditional standards – an innovative solution for the near future of sustainable housing in the Netherlands.

Ingenious new improvements in building detailing – triple glazing, super insulation, the lack of cold bridges and good airtightness – together with smart heating and ventilating systems (high performance DHW systems with thermal solar collecting and efficient heat recovery air systems) reduce energy consumption and at the same time both improve the indoor climate substantially and make a fundamental contribution to protecting the environment.

Some of the additional energy demand can be generated – as an optional feature – by a few photo-voltaic panels (5 m² house type E and 18 m² house type A).

Figure XI.ii - Solar houses Rivierdijk type E, F and E

Building construction

As a result of the fact that this project is built in the body of the dike which is constructed on more than 15m of soft peat ground below sea level, and because of the pressure on the dike caused by heavy rainfall upstream on the rivers Rhine and Meuse, it was necessary to make the concrete pile foundations extremely heavy.

For that reason, the total basement is made of monolite reinforced concrete; the upper level structures of these dike houses are mainly made of light weight (1700 kg/m³) concrete wall elements and slab concrete floors. The roofs are also made of prefab concrete hollow roof elements. In order to avoid thermal bridges, the total house-bearing construction is built on the load-bearing thermal insulation Purenite (layer of light Pu recycling foam, 0.7 – 1.8 N/mm²; x = 0.075/0.105 W/m²K). The whole structure – ground floor, facade, roof – is covered by 30cm of polystirol insulation; excluding the basement, which has 15cm rigid resol foam insulation and an exterior wall of brick masonry. The upper part of the house facades are completely covered with mineral plaster.

The overall foundation/wall/roof construction achieves a calculated U-value of 0.138 W/m²K (basement), 0.116 W/m²K (upper façade), 0.116 W/m²K (roof). Special care was given to reduce the remaining thermal bridges.

All large south-facing windows and balcony terrace doors have integrated sun-shading systems. The wooden window frames and isolated doors (U= 0.93 W/m²K) have triple glazing (selective surface and filled with Argon gas U-value 0.6 W/m²K).

Due to the good insulation performance, in combination with the internal masses and the outside sun shading devices, the house is protected against over-heating in summer and it can receive as much passive solar heat as is desirable in winter time.

Technical systems

Controlled air supply and extraction with heat recovery: the heat recovery unit (WHR 950 J.E.STORKAIR with 100% bypass, 88% efficiency, PHI Certificate), together with the F7 air filter box, the water-to-air supply air-heater unit and the gas-burning DHW system (high performance Solar Gas Comb II ATAG), combined with the solar hot water storage tank (200 litters, 80 l DHW + 120 l solar part storage), connected to 4.23 m² flat plate thermal solar collector on the roof.

The excellent air tightness of the houses is one of the essential pre-conditions for passive houses. During the erection of these solar houses, the main concrete construction and the connection with window and door frames were heavily taped shut to achieve the necessary air-tightness, which is also crucial for passive houses in the windy Dutch climate.

Energy performance

The following calculations are based on the spread sheet calculation test for the passive house planning package.

- heating of space and ventilation air
  15 kWh/m²a
- domestic hot water (solar energy covers 55% of the demand)
  21.9 kWh/m²a
- fans and pumps
  15.1 kWh/m²a
- lighting
  11.5 kWh/m²a
- appliances
  53.6 kWh/m²a

Total energy demand
117.1 kWh/m²a

Costs

The first careful conclusions show us that in this project the building costs of these 12 passive solar houses are 4.7% higher compared to the Dutch standard building costs for the 11 conventional houses in Sliedrecht built on the same site at the same time in the same housing project.

Marketing strategy

To market this project, no special information was given about the high performance of these 12 solar houses. Just the usability of the plan, the location in the dike (more privacy), the living conditions and the good price/quality relation convinced the new owners to buy all these 12 solar houses, which were sold before the completion date (October 2004).

Summary

The comfortable indoor living conditions, in combination with low-operating costs for heating consumption, makes these houses ready for the future; they are user-friendly, have a positive performance in their building environment, and protect the quality of their and others' environment by using appropriate technology in combination with good architecture.

Information

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Foundation Passive House Holland, Bruchem

Case Study 2: Family House Waaldijk, Dalem, the Netherlands

Family House Waaldijk based on passive house technology.

In 1995, the river dikes almost collapsed because of the large amount of river water coming down from the Rhine. A special law was accepted to strengthen and raise the Dutch river dikes. Because of this, the habitants of an old house in Dalem, on the inside hang of the dike, lost their nice view over the Waal River, an old castle and the little old town on the other side. They decided to build a new more comfortable private house on the same location, to give them back their magnificent view.

This had to be a house for the future, with easy access for elderly people, where they could live as long as possible in a comfortable and healthy way in combination with low costs for energy consumption and maintenance based on the energy efficient Passive House technology.

The light weight concrete main structure of the extended walls is covered with 300mm EPS insulation and finished with a mineral plaster (U=0.115 W/m²K); insulated windows, window frames and doors (U=0.68 W/m²K), together with integrated sun shading systems in the large south and east facing windows; 300mm EPS roof insulation (U=0.116 W/m²K) on the roof and 300mm EPS insulation on the floor (U=0.113 W/m²K) make a perfect insulated envelope around the living areas of this passive house of which the exterior building connections are designed to avoid thermal bridges.

The living room, kitchen, bathroom and main bedroom are connected with the main entrance, which can be reached by a long walkway from the road on top of the dike. The living room and the kitchen have access to a transparent balcony and a steel and wood terrace structure; underneath the overhang of the main floor is space for car parking. Through a horizontal earth heat exchanger of about 30m in the dike, fresh air flows into the ventilation and heating system which easily covers the total energy needed for space heating.

Figure XI.iii - Family House Waaldijk, Dalem, the Netherlands

A system with heat recovery and auxiliary space heating using a water to air heat exchanger applied to the fresh air intake. And also the use of renewable solar energy for domestic hot water heating demands. A special, insulated body shaped, bath lowers the demand for domestic hot water energy that is mainly collected by 4.23 m^2 of flat solar collectors on the roof. There are only two small radiators, one in the basement and one in the northwest facing bathroom.

This house was built as a pilot project by the Dutch Foundation of Passive House Holland. This foundation was formed to encourage the development and realization in Holland of the so-called “Zonhuizen”, special solar houses based on the passive house technology (already in use mainly in Germany and Austria) as one of the most promising energy concepts for the future.

The foundation was formed in 1998 by 8 companies in the building sector: 5 manufacturers, 1 installation company, 1 consultant in installations and building physics and 1 architect.

Figure XI.iv - Family House Waaldijk, Dalem, the Netherlands

Energy performance

Because of the little compact shape of the house and the relative large exterior surface, due to being built on piles, this project didn’t reach the passive house targets but still is a very good example of the application of passive house technology.

PHPP (D)

The following calculations are based on the spread sheet calculation test for the passive house planning package (PHPP). These very detailed calculations and assumptions from the PH Institute in Darmstadt are more in harmony with this passive house technology for very low energy consumption and the annual energy demand:

- Heating of space and ventilation air
  25 kWh/m^2a
- Domestic hot water (solar energy covers 55% of the demand)
  15.1 kWh/m^2a
- Fans and pumps
  18.9 kWh/m^2a
- Lighting
  11.7 kWh/m^2a
- Appliances
  48.0 kWh/m^2a

Total primary energy demand
118.7 kWh/m^2a

First monitoring results 2001 – 2002, Passief Huis Dalem (BEC 13-01-03):

- Heating and space and ventilation air 31 kWh/m^2a
- High appreciation, especially of the indoor climate conditions, by the occupants

Information

Private principal – Mr. v.Duyvenbode and Mrs. Ploegmaker
Architect (contactperson) - Franke Architekten BV (proj.arch. ir. Erik Franke)
Building, serv.,techn. - Aannemings bedrijf J.A.de Jager Groot-Ammers

National conclusions

Natural gas is the today main energy source of the Netherlands. Besides the importance as an energy source, this also supports the Dutch government with an annual income of approximately €10 billion. The today strategy is to refill empty gas fields with (Russian) natural gas, and to create the European roundabout of natural gas distribution. To reduce the CO_2 emission of this natural gas policy, expensive research has started on Carbon dioxide Capture and Storage (CCS). Cities which are situated above empty gas fields where CCS is planned set against this research. CCS is a large scale solution, for power plants for example, which can not be used on building scale. Buildings can be heated with zero carbon heat from heat distribution networks which are linked to heat power generation plants with CCS. The Passive House (in Dutch Passief Huis) concept, as shown in this paper, can reduce the heat demand as much as possible. The market leading construction companies accept the Passive House concept with open arms, fitting well to the Dutch business as usual policy to continue with their natural gas strategy, combined with zero carbon heat distribution networks and with CCS heat power generation plants.

The Dutch EPBD implementation is already briefly described in this paper. The following information gives the first insights of a running research project in which sixteen European, including the Dutch, EPBD implementations are compared.

The European IEE research project Assessment and Improvement of the EPBD Impact (ASIEPI), for new buildings and building renovation, is a cooperation of sixteen European countries, to compare the building energy targets of these sixteen countries. The first outcomes claim that it is difficult to define comparable reference houses with equal floor areas and energy loss surfaces. A 100 kWh/m^2 electricity consumption in Denmark can mean a 20 to 25% higher electricity consumption compared to France for example. Another difference is caused by the energy values which are calculated. In Finland, and even in Italy, cooling energy is not included for example. In Spain cooling energy is included, but the heat and cool equipments are not. Some countries do not include the energy values for hot potable water, fans, and lighting. Minor energy values differences of these countries are about the definitions of cold-bridges, air-tightness, equipment efficiency, heat recovery, and ventilation volumes. Another issue which makes comparisons more complicated are the rather large climate differences in Europe (TNO Spiekman).

XII Norway

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National context

Norway is a parliamentary constitutional monarchy, as the other 2 Scandinavian countries, Denmark and Sweden. Norway is responsible for the administration of the Svalbard islands in the Arctic.

Geography

The country comprises the western part of the Scandinavian Peninsula. Norway stretches farther north than any other European country except Russia, covering latitudes from 58ºN to 71ºN (Svalbard 78ºN to 80ºN). The country is quite mountainous, with a very rugged coastline, dominated by fjords formed by glaciers during the ice ages. The length of the coastline, including all islands, is over 83,000 km, longest in Europe.

The land area is 324,220 km^2, about the size of UK or Italy. Of the mainland area, around 1/3 is forested; only 3% is arable. The rest is mountains, lakes, heaths, bogs etc.

Climate

The climate is surprisingly mild, given the high latitudes. The climate of the mainland is temperate to cool, with large temporal and geographical variations. The coastal areas have cool summers and mild winters, with much precipitation, up to 3-5m. The inland areas enjoy warmer summers, but also colder winters, and much lower precipitation, locations in the "rain-shadow" as low as 300mm/a.

Demographics and economy

The population reached 4.8 millions in 2008, giving a density of around 15 persons/km^2, one of the lowest in Europe. The life expectancy is over 79 years.

Norway is in many aspects a wealthy country, the GDP is Euro 192 billion (2007), above Euro 42,000 per capita. Norwegians enjoy a well-developed welfare system. The country has scored no.1 on the UNDP Human Development Index several years

Locations 1: Central East 2:Interior North 3: Svalbard	Annual temp.ºC 1961-90	Annual temp.ºC 2007	Degree days base +17ºC 1971-2000
Oslo	5.7	7.2	4041
Stavanger	7.4	8.6	3380
Bergen	7.6	8.4	3530
Trondheim	5.0	5.7	4339
Røros[1]	0.3	1.4	5921
Tromsø	2.9	3.9	5027
Karasjok[2]	-2,4	-0.8	6897
Longyearbyen[3]	-6.0	-2.5	8122

Table XII.i – Temperature data for some locations in Norway ranging from 58°to 78°N

About one third of the GDP arises from the petroleum sector. Otherwise, metals, fish and shipping are important industry sectors. The state surplus is invested in an international pension fund.

Energy

Norway enjoys an abundance of energy supplies: petroleum, hydropower, the largest wind potential in Europe, coal (Svalbard), and biomass (firewood).

About 95% of the oil and gas production is exported to other countries in Europe, making Norway the 3rd or the 4th largest exporter in the world. The electricity supply has up to now been totally based on hydropower. This is now changing, as the electricity demand is still increasing while there is basically full stop in development of more hydropower. During dry periods, therefore, Norway imports some power from neighbouring countries, and there are several gas-fired power plants under planning. A most important political issue now is how to implement CO_2 capture technology in these plants.

The energy end use in Norway after sources (2007):

- Electricity 50 %
- Petroleum: oil, gas 39 %
- Coal, coke 5 %
- Firewood, refuse, district heating 6 %

A large part of the electricity demand in Norway is due to the fact that a great number of buildings are heated electrically, especially dwellings. Therefore, the government has launched programmes to increase the use of water-based (hydronic) heating systems, and also subsidize heat pumps.

Greenhouse gas emissions

The total annual emission of GHG in Norway is about 55 $MtCO_2e$ (2007), which is about 12 tCO_2e per capita. This places Norway quite high on the list of the worst GHG countries. The main sources are the petroleum sector (25%), transportation (30%), and industry (20%). The construction sector and the operation of buildings are responsible for a fairly low share of the emissions, mainly due to the fact that the dominating energy use is hydropower electricity.

Building regulations

The building regulations in Norway are legally covered by the Planning and Building Act of 1985 with later amendments. The law authorizes the Ministry of Local Government and Regional Development to enforce Technical regulations which also include energy use in buildings.

EPBD implementation

New Technical Regulations for the construction sector that implements the EBPD were adopted and enforced from 1st February 2007. The industry has been given a 2.5 year transition period where the old regulations may be used. All new projects after 1st August 2009 will have to satisfy the new regulations.

Calculation method

The national calculation methodology has been launched in a new Norwegian Standard. NS 3031:2007 "Calculation of energy performance of buildings method and data" was adopted in October 2007, and gives the framework for the calculation. The standard complies with EN ISO 13790 and EN 15265, and gives details for a monthly method. Hourly calculation methods require validation, according to the standard. The calculation uses reference values for important input, such as internal gains, climate (Oslo), operation schedules, hot water demand etc.

The calculation method shows how to calculate net energy demand, delivered energy, primary energy and carbon emission. The primary energy issue for electricity is somewhat complicated in Norway now, see above. Therefore, the present EPBD proposal does not include primary energy requirements, but the issue will be raised again later. For CO_2 emission, the standard refers to EN 15603.

Energy performance requirements

The code requirements can be satisfied according to 2 different models: the framework requirements and the energy measure requirements.

1. The framework requirements model

This model sets a maximum framework for net energy demand for 13 different building categories, given as kWh/m^2a for the heated floor area. The framework comprises all energy uses in the budget, i.e. heating, cooling, ventilation, hot water, lighting and equipment:

Building category	Max net energy demand
Detached houses +1600/heated floor area	125kWh/m²a
Blocks of flats	120 kWh/m²a
Kindergartens	150 kWh/m²a
Office buildings	165 kWh/m²a
Schools	135 kWh/m²a
Colleges, universities	180 kWh/m²a
Hospitals	325 kWh/m²a
Nursing homes	235 kWh/m²a
Hotels	240 kWh/m²a
Sports buildings	185 kWh/m²a
Retail buildings	235 kWh/m²a
Cultural buildings	180 kWh/m²a
Light industry, workshops	185 kWh/m²a

2. The energy measure requirements

This model implies that a standard set of energy conservation measures has to be incorporated in the new building. These measures are the same as those used for calculating the reference values for the framework requirements above:

- Total max. area of windows, doors, glazed walls and roofs: 20% of floor area
- Max. U-value of external walls: 0.18 W/m^2K
- Max. U-value of roof: 0.13 W/m^2K

- Max. U-value of slab on ground: 0.15 W/m^2K
- Max. U-value of windows, glazed walls and roofs, and doors (average): $1.2 W/m^2K$
- Max. specific therm. bridging per heated floor m^2:
  For detached dwellings: 0.03 W/m^2K
  For other buildings: 0.06 W/m^2K
- Air tightness: max air change at 50 Pa pressure:
  General requirement: 1.5 ac/h
  For detached dwellings: 2.5 ac/h
- Min. annual average temperature efficiency of air heat recovery: 70%
- Max. specific fan factor for ventilation fans:
  Commercial bldgs. day/night: 2.0/1.0 kW/m^3s
  Dwellings, 24 hr operation: 2.5 kW/m^3s
- Automatic external shading or other measures that will ensure thermal comfort without local cooling.
- Night and weekend setback of internal temperature to 19^o C (17^o C for sports facilities) for buildings where division between night, day and weekend operation can be identified.

For this model, energy calculation is therefore not normally necessary. However, it is possible to reduce the level of one thermal energy measure by compensating with a higher level of another measure. For example, log external walls are accepted if the extra heat loss is compensated through better windows or roof insulation than the reference values above. The net heating demand for this "exchange" of measures has to be documented by calculation.

Energy supply

The new regulations demand that a substantial share (min. 40%) of the heating load should be covered by other sources than electricity or fossil fuels. Buildings with extraordinary low heating demand may be exempt from this rule, the definition here is below 15,000 kWh/a. Dwellings under this exemption shall be equipped with chimney and closed fireplace.

Energy performance certificates

Implementation of Article 7 of EPBD requiring Energy Performance Certificates will legally need changes in the Energy Act of 1990. A proposal was issued in December 2008, and it is expected that the Norwegian parliament will adopt the changes in the spring of 2009. The regulations for certificates will most likely be enforced from 1st January 2010.

For dwellings a certificate is needed for sale or rental, it can be issued by the building owner. Commercial buildings above 1000 m^2 will always need a certificate, and the person responsible for issuing the certificate must document his/hers competence.

The certificate will give the building a ranking on a scale similar to the one used for household appliances, see the proposal below. Quality level C will correspond to the new technical requirements from 2009. A web-based tool will be available for the calculations necessary for the certificate.

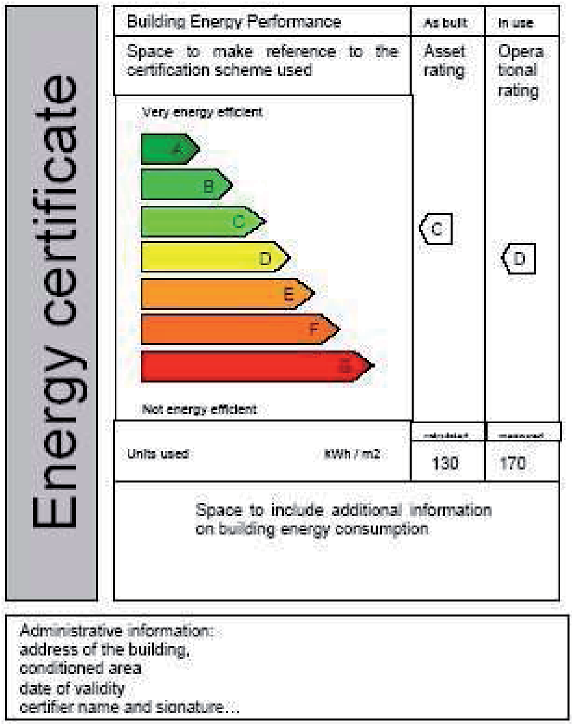

Figure XII.i –Draft energy certificate for buildings, according to EPBD

Inspection of systems

The inspection regulations will operate from the same date as the energy certificates. Only commercial buildings will be mandatory.

Other initiatives

The ministry responsible for the technical building regulations has announced that revisions to stricter energy numbers will be introduced regularly every 5 years from now. Reaching low-energy and passive-house levels will be discussed next time, and special provisions will be implemented for zero energy and zero emission buildings.

Case study 1: BP Solar Skin

Background

In order to show the public that BP is also developing renewable and sustainable energy, BP Norway asked R&D institutions in Norway for ideas that would further this cause. The NTNU members of COST C23 came up with the idea to develop a façade system, based on a combination of building integrated PV (BIPV) and double facades. The concept was examined in feasibility studies. A suitable south-facing façade on an existing university building in Trondheim was chosen as site for the prototype.

This case study is thus a prototype for new façade systems added on to an existing building.

The building

In the proposed building system the PV cells are integrated in the outer glass skin. The performance characteristics of the two combined façade concepts are complementary – the systems help each other if controlled properly. Some important features of the BP Solar Skin concept are:

- Both electricity and thermal energy are provided,
- The PV cells convert solar radiation to electricity,
- The thermal energy will reduce the heating load,
- The PV cell provide solar shading,
- The cavity can be used in natural ventilation,
- The cavity can be vented for better PV output,
- The cavity provides protected location for solar shading systems,
- The skin and the cavity provides noise protection,
- The cavity enables operable windows,
- The cavity can be supplied with platforms for maintenance and evacuation,
- The concept is suited for thermal upgrading and protection of existing facades.

The BP Solar Skin concept also implies some problem areas: fire safety, sound propagation, reduced daylight levels, and impairment of view.

The prototype was erected on an existing NTNU university building, key data are:

Total façade area	455 m^2
PV module area	192 m^2
PV cell net active area	108 m^2
Cavity width	0.8 m

Figure XII.ii - The prototype BP Solar Skin façade at NTNU, Trondheim

Decision making

The design of the BIPV prototype called for a multidisciplinary approach, as many technical and human factors are important aspects. The design team therefore incorporated many different professionals: architects. HVAC/energy engineers, structural engineers, PV/electrical engineers, fire and sprinkling system engineers, daylighting experts, and glazing system experts.

The project was managed by the NTNU-members of COST C23 and financed by BP Norway, other industry participants and the Norwegian Research Council.

Cost analysis

This façade concept is meant to be a cost-effective alternative to thermal up-grading of existing facades (new windows, new cladding, improved air tightness, added insulation etc.), where the investment costs should balance the costs of conventional upgrading.

This was, however, not demonstrated in the prototype, as several cost-relevant factors were not favourable: windows and solar shading had just been replaced, and a new ventilation system installed, just before the prototype was built. Total costs for the project was €516,000 or €1,135/m^2 façade. The PV system alone accounts for about one third.

Carbon analysis

A complete carbon analysis for this case study has not been performed, it would include comparing the carbon impacts of the invested materials (steel, glass, aluminium, PV cells, cabling etc.) with the carbon savings from the reduced thermal demand and the electricity produced. For a Norwegian case this will be quite different from other European countries, as both aluminium and PV cells are produced domestically with renewable electricity.

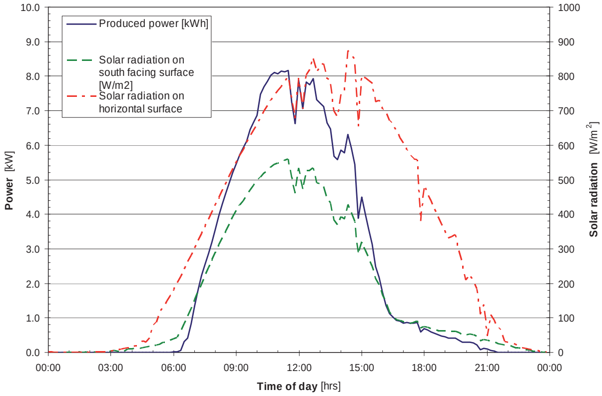

Figure XII.iii - Monitoring results for June 23. 2001. The solar radiation vertical south was about 550 W/m2 at 12 (green curve). The measured power from the PV cells was about 8 kW (blue curve).

The electricity produced was monitored to around 7200 kWh/a, around 75% of the expected performance. The losses are mainly due to shading from trees at the site. The thermal savings were calculated on the basis of cavity temperatures to 7-8% of the full demand.

Key points

The BP Solar Skin project has demonstrated that the concept is a viable alternative to conventional improvement of existing facades. The architectural challenges and opportunities are large, the energy saving potentials are considerable, but not very large. The costs are high, but could be reduced if one opts for a double skin façade without PV cells integrated. The PV output could be improved much, maybe doubled, with a smaller spacing between the individual PV cells, but this would again increase the costs and reduce visual comfort. As PV cells become more efficient and less expensive, the potential for benefits from this concept will improve greatly.

Technically, the prototype has functioned as expected since installation in 2000. The cavity is vented when temperatures reach levels above comfort. The occupants in the upper floor have experienced some summer discomfort during unfavourable wind conditions.

Case study 2: Løvåshagen passive house apartments

Løvåshagen is a dwelling development in Bergen on Norway's west coast, consisting of 28 apartments built to the German Passive House standards, and 52 apartments built to low-energy standards. The dwellings were completed in 2008, the apartments vary in size from 50 to 95m^2, the average size being 80m^2. The climate at the site is generally mild and moist, mean ambient temperature is +7.8ºC, winter design temperature is -10ºC, and mean solar radiation on horizontal surface is 760 kWh/m^{2}a.

The buildings

The passive house apartment buildings are 2-3 storey high, with in-situ concrete floor slabs, double wood frame exterior walls, and wooden I-beam roof construction. Special attention was placed on achieving air tightness and low thermal bridging. Balconies and exterior access walkways were in principle separated fully from the insulated envelope.

Each apartment has a mechanical ventilation system with rotary wheel heat recovery. The heating system is water based and supplied from 3.2m^2 vacuum tube solar collectors on the roof, with electric back-up. The apartments are also equipped with a simple in/out button that sets the mechanical systems in a sleep mode when the occupants leave their home.

The thermal performance targets for the building are:

- Exterior walls, 350-400 mm insulation, U-value 0.10-0.12 W/m^{2}K
- Roof, 500 mm ins., U=0.08 W/m^{2}K
- Slab on ground, 350 mm ins., U=0.08 W/m^{2}K
- Windows, triple panes, 2 LE coatings, argon, super spacer, insulated frame, U-value 0.7-0.8 W/m^{2}K
- Doors, U=1.0 W/m^{2}K
- Thermal bridging 0.015 W/m^{2}K
- Air tightness 0.6 ac/h at 50 Pa
- Specific fan factor 1.5 kW/(m^3/s)
- Heat recovery efficiency 80-83 %

Air tightness tests have shown performance in the range 0.5-0.8 ac/h.

Figure XII.iv - The Løvåshagen dwelling development, the passive apartments with solar collectors in front

Cost analysis

The extra costs over building code standard construction are estimated at NOK 1,000-1,200/m^2 (€120-150/m^2), which accounts to 5 - 6% additional costs. The payback time is not reported.

Carbon analysis

The German Passive House standard calls for a heating demand below 15 kWh/m^2a and heating power below 10 W/m^2a. The primary energy demand should be less than 120 kWh/m^2a, when electricity demand is multiplied by 2.5. This is not really correct for Norway, where almost all electricity is generated by hydropower.

The Løvåshaugen passive apartment blocks have a calculated heating demand of 12.8 kWh/m^2a and a heating power demand of 11 W/m^2a. The total energy demand for one passive apartment is calculated to 91 kWh/m^2a, which broken down to different energy budgets are:

- Space + vent. heating 15 kWh/m^2a
- Tap water heating 30 kWh/m^2a
- Fans and pumps 6 kWh/m^2a
- Lighting 17 kWh/m^2a
- Equipment 23 kWh/m^2a

The solar system covers 17 kWh/m^2a, the net electricity demand is thus 74 kWh/m^2a.

Key points

This dwelling development is the first Norwegian attempt to build multifamily apartment blocks to passive house standards. Monitored performance numbers are not yet available, but the calculated performance gives very impressive figures.

The passive dwellings demanded more design and quality control efforts than conventional construction, but the costs for this was more than covered by much better overall quality. There were no serious technical difficulties in construction of passive standard apartments in the Bergen climate.

Planning legislation

The total annual emission of GHG in Norway is about 55 MtCO_2e (2007). The main sources are the petroleum sector (25%), transportation (30%), and industry (20%). About 70% of the emissions are energy related, the rest stems from processes. The construction sector and the operation of buildings are responsible for a fairly low share of these emissions, mainly due to the fact that the dominating energy use is hydropower electricity.

The current trends in GHG emissions are increased total levels, but the emissions have levelled off lately. This is true for the petroleum sector and the process industry; combustion sources show a decrease lately. The one sector that still is increasing is transport (mobile sources).

GHG emissions are legally regulated by laws and regulations covering pollution. For fossil fuels the government now imposes a CO_2-tax which may reach €0.05-0.10 per litre. Some industries have accepted "voluntary" agreements on emissions, and the government also encourages purchase of CO_2 quotas.

The current government has recently announced a very ambitious plan for reduction of GHG emissions, and reached an agreement with most of the opposition parties in the parliament. The plan calls for an overreach of the Norwegian Kyoto quotas by 10% in 2012. Within 2020 the emissions shall be cut by 30% below the 1990 reference level. This implies that the GHG emissions should be cut by 15-17 MtCO_2e by 2020. The government also invites other countries to aim for carbon neutrality in 2030.

In Norway, the location and design of buildings is regulated according to the Planning and Building Act. According to this Act, it is forbidden to establish buildings and technical infrastructure (except for agricultural purposes) in areas set aside for non-development in the municipal master land use plan (i.e. the combined land use category of agricultural, natural and outdoor recreation areas). By avoiding setting aside excessively large areas for development and keeping the developmental areas concentrated not allowing for leapfrog development, municipalities can use the planning legislation actively to prevent urban sprawl.

Within the zones set aside for development, the master plan usually distinguishes between different types of land use, such as residential, industrial, commercial, public, outdoor recreation. Setting aside areas for combined land use is also possible, e.g. combined residential and commercial land use. The detailed content and design of development on specific sites is regulated through local development plans.

The Planning and Building Act allows the State to establish so-called National Policy Provisions in order to secure important national concerns in land use and infrastructure planning. Among the handful of such Policy Provisions that have been adopted since this legislation was established in 1985, the National Policy Provisions on Coordinated Land Use and Transport Planning issued in 1993 are the most relevant ones within our context.

These Provisions instruct the municipalities to plan their land use and development in a way that limits the need of transportation and facilitates the use of public and non motorized modes. Moreover, emphasis should be placed on achieving solutions which imply that everyday errands can be carried out at a short distance from home, and at defining clear limits between built-up areas and agricultural areas, nature areas and areas for open-air recreation.

According to the Provisions, efforts should be made as far as possible in order not to spread the encroachments into nature. In additions to the above requirements to prevent urban sprawl, the Provisions also include requirements aiming to contribute to a more environmentally friendly transport infrastructure planning. In regions or areas where the density of the population provides a basis for public services as an environmentally friendly and effective form of transport, it is, according to the provisions, necessary, when planning the spatial pattern of development and the transport system, to attach special importance to conditions that encourage public transport. When the capacity of the road network is insufficient, equal consideration shall be given to alternatives other than increasing the capacity of the roads, such as, regulating the traffic and improving public transport services.

The Planning and Building Act also includes several by-laws. From a low carbon perspective, the Regulations Concerning Requirements for Construction Works and products for Construction Works are of particular interest. These regulations include a chapter on Use of Energy, focusing in particular on thermal insulation, but also requiring energy and environmental considerations to be made when choosing construction materials, and with requirements regarding air tightness and indoor climate. The government has announced that this legal instrument may be used to outlaw the use of fossil fuels for heating purposes in buildings.

Urban case study: Oslo

Reducing the need for motorized travel – in particular travel by the private car – through dense and concentrated urban development makes up an important part of the rationale for the so-called Compact City Model. However, according to several authors, metropolitan-level decentralization of workplaces and residences is a strong and more or less general tendency in Europe. This does, however, not apply to countries like Sweden and Norway, where a long period of spatial urban expansion since the 1950s has been succeeded by a trend of re-urbanization during the latest couple of decades.

Figure XII.i shows how population densities have developed within the continuous urban area of Greater Oslo (below) and within the part of this urban area belonging to the Municipality of Oslo (above) from 2000 until 2008. For Greater Oslo as a whole, the urban population increased from 773,000 in 2000 to 857,000 in 2008, while the urban area expanded from 269 to 285 km^2.

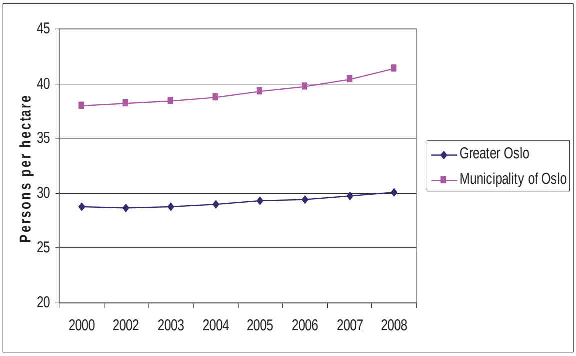

Figure XII.v - Population densities 2000 - 2008 within the continuous urban area of Greater Oslo (below) and within the urban area of Municipality of Oslo (above). Persons per hectare. Source: Statistics Norway, 2008

Accordingly, the population density within the urban area increased from 28.7 to 30.1 persons per hectare. Within the municipality of Oslo, which makes up the central part of Greater Oslo, covering 47 % of the urban area and including 65 % of the urban population, the density increase was substantial. Here, the urban population density increased from 37.9 persons per hectare in 2000 to 41.4 persons per hectare in 2008. This reflects an increase in the urban population from 504.000 to 558.000, accompanied with a modest increase in urban area from 133 to135 km^2.

Within the municipality of Oslo, the construction of dwellings as well as commercial buildings has to a high extent taken place in the inner and central parts. In particular, a high proportion of residential development has taken place within 4.5 km from the city centre. Commercial development has also mostly taken place within this radius, but with a lower proportion in the innermost areas, compared to housing construction. Instead, considerable development has taken place around public transport nodes about 4 km away from the city centre, mostly on derelict or low-utilized industrial areas. One of these nodes (in the northern part of the inner area) has been established as a result of a new metro ring opened in 2006.

Why has Oslo pursued such a strong densification policy, contrary to allegedly irresistible decentralizing forces? A strong focus on coordinated land use and transport planning in order to reduce energy use and emissions from transport is no doubt an important part of the explanation. In addition, social and cultural conditions necessary for implementing such a strategy have to a high extent been present.

According to the Norwegian planning legislation, it is forbidden to establish buildings and technical infrastructure (except for agricultural purposes) in areas set aside for non-development in the municipal master land use plan (i.e. the combined land use category of agricultural, natural and outdoor recreation areas). By avoiding to set aside excessively large areas for development and keeping the developmental areas concentrated not allowing for leapfrog development, the municipalities of Oslo Metropolitan Area (in particular the Municipality of Oslo) have used the planning legislation actively to prevent urban sprawl.
Protecting outdoor recreation opportunities in the forests surrounding the city has been an important part of the motivation for this containment policy. Within the zone set aside for development, the master plans have been more flexible, leaving considerable room for negotiation between the municipal authorities and developers about the content and design of development on specific sites. The latter has been legally regulated through local development plans. An important point in case is, however, that the limited possibilities for urban expansion ensured through the master plans have increased the motivation of developers for embarking on brownfield transformation projects.

Also, there has been a rising popularity for urban living, especially among young people and middle-age people whose children have moved away from home. Given the restrictions established through the narrow demarcation of the “building zone” laid down in the master plan, the market mechanisms have to a high extent pulled in the same direction as the municipal plans, resulting in densification in particular in the central part of Oslo and around major public transport nodes.

City case study: Trondheim

Trondheim is the third largest city in Norway, after Oslo and Bergen. Historically, the city was capitol in the Viking and early Medieval period. The cathedral built on St.Olav’s grave became a major pilgrimage point. Olav was killed in a battle in this part of the country in 1030 while attempting to Christianize the population.

The city’s economy is based on trade, some industry and many educational facilities, including Norway’s only technical university, NTNU.

General city data

The old city is built on the estuary of the local river, facing a major fjord. The city has grown from this flat low-altitude area, first up in the surrounding hills, later up the river valley. Some general city figures are given below:

Location:	Latitude:	63.5ºN
	Altitude urban area:	1–200 m
Climate:	Temperature 1961-90:	+5ºC
	Rainfall:	850 mm/a

Resident population:	1991:	140,000
	2001:	150,000
Employment:	1991:	70,500
	2001:	83,000

City/metropolitan surface area:	60/320 km^2
Green area within city:	13.8 km^2
Population density 2001:	470 p/km^2
Employment density 2001:	260 workplaces/km^2

Employment sectors:	1991	2005
Agriculture	2%	1%
Mining, manufacture, energy	12%	10%
Construction	6%	7%
Trade, accommodation, catering	18%	19%
Transport	8%	7%
Finance, insurance	8%	15%
Public service	44%	41%

Building stock

Trondheim is basically a low-rise fairly low density urban city. The historical parts are dominated by 1-3 storey wooden houses, supplemented by infill of newer and higher buildings. Very few buildings reach 12 floors. Newer housing developments are typically low-rise (3-5 floor) blocks of apartments. Some figures for dwellings are:

Dwellings (number of units)	1991: 61,000
	2001: 69,000
New construction dwellings:	1991: 560
(units)	2001: 920
	2005: 1945
Average age of dwellings:	2002: 38 years

Land use and urban form

The shape of the urban development is governed more by the local topography than by any planning concept. New development after WW2 has lead to considerable urban sprawl, which again results in a large road network and problems with development of satisfactory public transport.

Transport systems

Public transportation in Trondheim is based on buses, some of which are operated on natural gas. The city has one tram line that operates from the city centre westwards into the recreational areas.

Motor vehicles per 1000 inhabitants:	1991:	380
	2001:	400

Resource consumption

Trondheim's annual energy use is around 4 TWh, this figure has been fairly stable 1990-2000, but increasing slowly. The main sources are:

Electricity	56%
Fossil fuels	34%
Refuse, biomass	10%

Figure XII.vi - Trondheim area plan 2008. Colour legend: ochre - city centre, yellow – existing built-up areas (mostly dwellings), blue – commercial areas, green – parks and other greenery, red – cemeteries, grey – communication areas

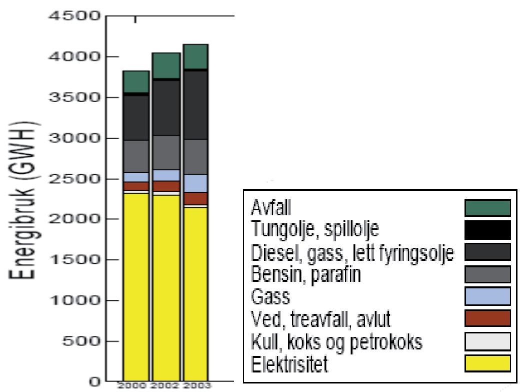

Figure XII.vii - Energy sources, 2000,2002 ,and 2003. Legend from top: Refuse, heavy oil, diesel/light oil, petrol/paraffin, gas, biomass, coal/coke, electricity.

The city has for Norway a rather large district heating system, based on burning of refuse, supplemented by gas and electricity. This covers around 25% of the heating load of the city.

Performance indicators

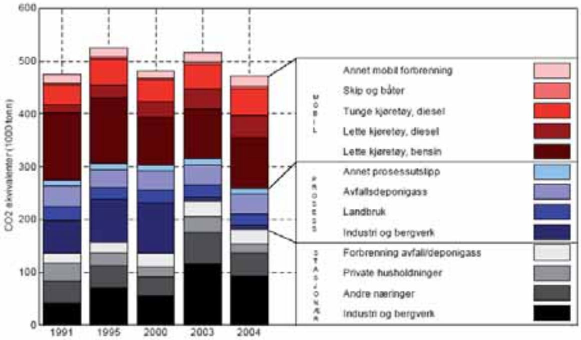

Figure XII.viii - GHG emissions in Trondheim 1991-2004, unit 1000 t CO_2e. Reddish colours: mobile sources, bluish colours: processes, greyish colours: stationary sources (combustion, households, industry)

The GHG emissions are fairly stable. The emission per inhabitant is decreasing, due to increased population:

1991:	0.497 $MtCO_2e$	3550 kg CO_2e/inhab
2000:	0.477 $MtCO_2e$	3180 kg CO_2e/inhab
2006:	0.476 $MtCO_2e$	3013 kg CO_2e/inhab

Recent environment projects

The city of Trondheim has recently announced an ambitious plan for improving the environment, and the city won the prize of the Norwegian Environment City for 2008, presented by the Ministry of the Environment.

The city's plan calls for many measures:

- Reduction of CO_2 emissions from traffic by 20% in the period 2008-2018,
- Increase public transport travels from 42 to 50%,
- Improvement of the pedestrian and bicycle pathways,
- Improved access and speed of public transport (buses),
- City development of increased density,
- Reduced CO_2 emission from municipality service traffic (electric and hybrid cars),
- Encouragement of other actors to participate.

The city has also increased the capacity of the district heating system, which now covers 30% of the total demand. About 70-80% of the energy is generated by refuse burning, and the heating plant will now store summer refuse for winter use. The recovery of household refuse is planned to reach 90%.

In the summer of 2008, special bus and taxi lanes were implemented on the major trunk roads into the city. This has created traffic jams during rush hours, but the city is hoping that the traffic problems will convince many commuters to choose bus instead of private car.

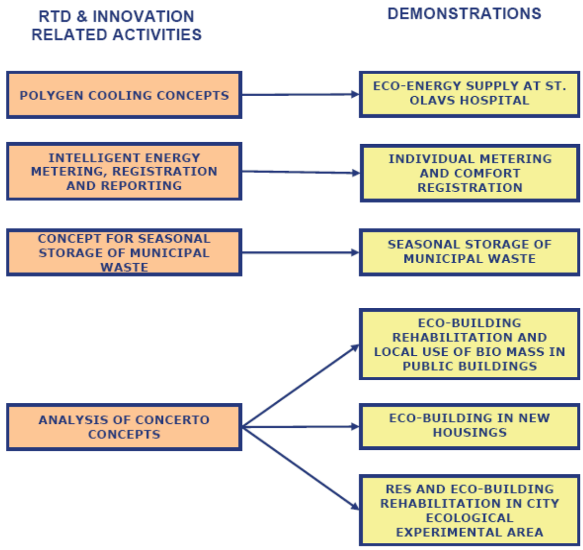

Figure XII. ix – Planned activities in Trondheim as part of the Eco-city participation

Trondheim is participating in the ECO-City project under the EU CONCERTO Programme. Some of the city's planned measures for the project is shown in the figure above.

Trondheim municipality has also decided to develop a fairly large centrally located land area with emission restrictions on all the buildings. The target for this sustainable urban settlement is to be carbon neutral.

National conclusions

When considering energy supply and use, Norway is in a unique situation among the European countries: a great surplus of oil and gas making the country an important exporter, almost all electricity from hydropower plants, a great almost untapped wind power potential, also a great wave power potential, good supplies of biomass (firewood) for combustion purposes, and even some coal supply from Svalbard.

But considering green house gas emissions, Norway is not doing so well. The transport sector is basically all powered by fossil fuels (road traffic, boat traffic, air traffic, part of the rail traffic), and the petroleum production sector is also responsible for a large share of the GHG emissions. In addition, the electricity supply from hydro power has reached its maximum because of environmental concerns, and therefore further increased demand will have to come from imported fossil fuelled power or domestic gas power plants.

Norway has adopted very ambitious plans to curb the emissions, both at national and local levels. Financially, the country should be in a good situation to carry out measures to this effect, but politically many tough decisions for implementation of measures to meet these targets, are still missing.

Some actions are, however, already underway. The new stricter building regulations which will be mandatory in 2009 will reduce the energy use in buildings substantially, and the government is pushing for even better performance in the construction sector. This will reduce the electricity demand and make the savings available for other sectors. It is also possible that heating with fossil fuels will be phased out.

In the transport sector, the official policy now is to raise taxes on petrol and diesel fuels and high consumption cars. The government is also supporting public service agencies in switching to electric cars, and there are great expectations for hydrogen cars.

To reduce GHG emissions from the petroleum sector, a measure under consideration is to build cabled electricity supply to all the offshore installations, a very costly option.

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XIII Poland

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National context

Poland lies in the central part of the European continent (52 N/20 E). The country has a continuous plain reaching from the Baltic Sea in the north to the Carpathian Mountains in the south, covering 311,888 km^2. Poland shares its borders with Ukraine, Russia, Belarus, Slovakia, Germany and Czech Republic. The country is divided into 16 major administrative provinces (*wojewodztwa*). Poland is a member of European Union, NATO, OECD, WTO and CEFTA. An actual status of building regulations is based on the new building law, Kioto protocol and the EPBD schedule of implementation.

Climate

Poland has a moderate climate with both maritime and continental elements. Generally, in the north and west Poland the climate is predominantly maritime, with gentle, humid winters and cool, rainy summers, while the eastern part of the country has distinctly continental climate with harsh winters and hotter, drier summers. Winters are cold, with average temperatures around 3 C in the northwest and −8 C in the northeast. The temperature varies with the seasons but seldom drops below −17°C or rises above 31°C (see, Figure XIII.i, average air temperatures). Hot days, when the temperature exceeds 25°C, occur from May to September. Poland is in a zone of variable winds predominantly western winds (southwest and northwest). East winds blow mainly in winter.

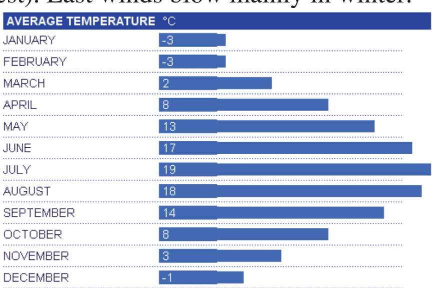

Figure XIII.i - Average annual temperatures in Warsaw [2]

The heating season in Poland averages 200-220 days, from mid-October to beginning-May. Typical value of *heating degree-days* [2] in Poland is estimated on 3470, comparing to 3250 in EU-25.

Demographics

According to the 2008 census, Republic of Poland with 38,116,000 inhabitants has the eighth-largest population in Europe. It has a population density of 122 inhabitants per km^2. The largest metropolitan areas in Poland are the Upper Silesia centered on Katowice (3.5 million inhabitants), the capital city, Warsaw (3 million), Kraków and Łódź (each 1.3 million), the Tricity of Gdańsk-Sopot-Gdynia in Vistula river delta (1.1 million), Poznań, Wrocław (each 900,000), and Szczecin (700,000).

Economic features

Poland is considered to currently have one of the fastest growing economies in CE nations, with an annual growth rate of over 6.0%. In 2007, the GDP came up to $623.1 billion dollars while per capita reached $ 13,300 dollars. The sources of GDP are: services 67%, industry 30% and agriculture 3%. Unemployment is falling rapidly, though at roughly 11.4% in 2007, but it remains well above the EU average. The natural resources are: hard and brown coal, sulfur, copper, natural gas, silver, lead, salt, amber, arable land.

Carbon dioxide emissions

In 2006 the total national emission of GHG gases was 400.46 Mt of CO_2-eq., excluding emissions and sinks from LULUCF (*Land-Use, Land Use Change and Forestry*), or 10.48 Mg per resident. This is 29 % lower than in the base year 1998. Pure CO_2 emission (except LULUCF) was accounted for 82.5% of total GHG emissions (8.65 Mg per resident), see Figure XIII.ii. An intensity of CO_2 emissions in Poland is compared in the Figure XIII.iii.

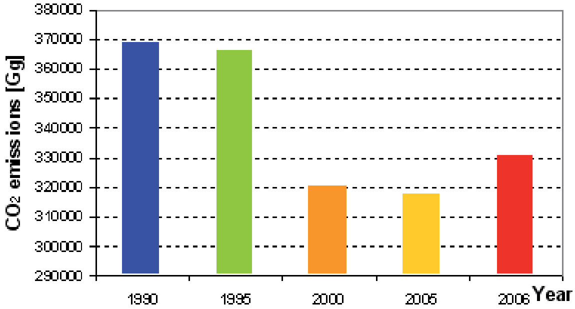

Figure XIII.ii - CO_2 emission data for in Poland

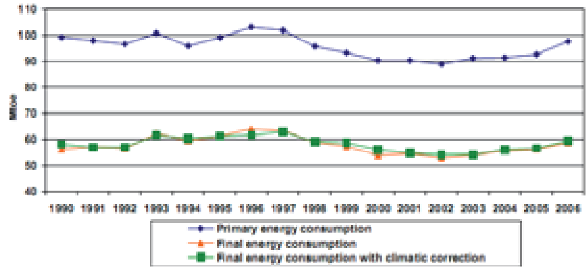

Figure XIII.iv - Primary and final energy consumption [1]

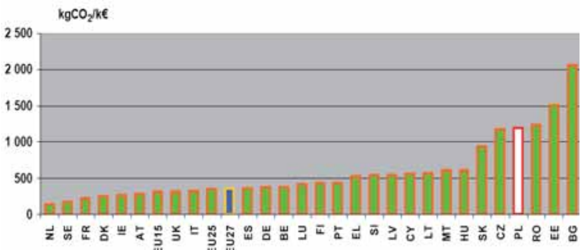

Figure XIII.iii - CO_2 emissions per unit GDP in EU countries

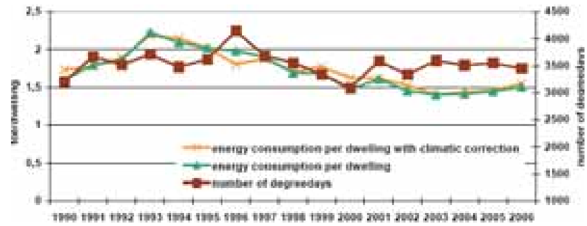

Figure XIII.v - Energy consumption factors in household [1]

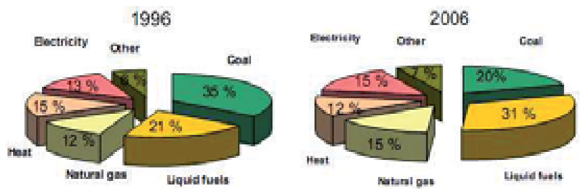

Figure XIII.vi - Final energy consumption by fuel type [1]

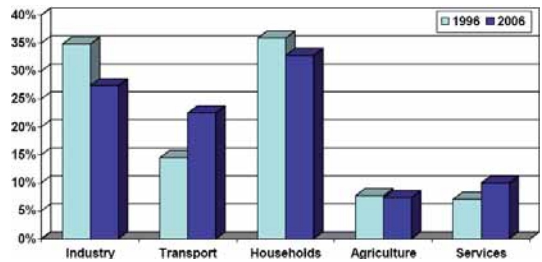

Figure XIII.vii: Final energy consumption by sectors [1]

Main CO_2 emission source is *fuel Combustion*. This sector contributed to the total CO_2 emission by 94 % in 2006. The shares of the main subcategories were: *Energy industries* – 56.7%, *Manufacture and Construction* – 10.2%, *Transport* – 11.3% and *Other Sectors* – 15.7%. A draft compromise on carbon dioxide emissions cuts, agreed upon at EU summit in Brussels in December 2008, stated that Poland will receive up to 70% of its emission allowance for free. The exemption will be gradually phased out by 2020.

Energy in Poland

Since 1992 the basic economic indicators and energy effectiveness in Poland have been improving. After growth in first half of the 90's, total primary and final energy consumption had decreasing tendency (Figures XIII.iv-XIII.vii). Decrease of energy consumption resulted from realization of modernization programmes, restructuring of economy and liberalization of energy prices as well as the energy efficiency improvement.

In energy field, Poland has customary been a supply-oriented with hard coal and lignite sector. However, the share of coal in energy consumption decreases systematically (Figure XIII.vi).

Natural gas and liquid fuels consumption slightly rose. In 2005, final energy consumption at the residential buildings was 216 TWh (30.7% of the total value). More complete statistical data on energy economy in Poland and other UE countries are collected in [1, 4].

Building regulations

Since 1st January 2009, Poland has got new building regulations relevant to the EPBD implementation (Directive 2002/91/EC). The Energy Performance

Certificates (EPC's) are required for the all new constructions and for the sale or rent buildings. Also, when in result of rebuilding or repair, the main energy characteristics of building have changed. In the Figure XIII.viii some data on the recommended U-values in UEU-25 countries are exposed.

Figure XIII.viii - Wall U-values in EU-25 country capitals after implementation of the EPBD in 2006

Since the beginning of 2008 new ordinances and legislation acts have been introduced in Poland as:

- 7th May 2008 - Ordinance of the Council of Ministers (CM) on the auction procedure for new investments in energy sector and energy saving initiatives (new rules of an auction procedure and its documentation);
- 28th May 2008 - Ordinance of the Ministry of Agriculture on the methods of recording the amount of harvesting plants for energy production (mass and volume measuring);
- 1th July 2008 - Ordinance of CM on conditioning CO_2 emission limits between to 2012 (E1-E3, F1-F2, M1-M3, O1-O2 codes, depending on industry branch and annual production). An attached Annex includes 838 companies;
- 14th August 2008 - Ordinance of the CM on an obligatory submission for extinguishing testimony of origin for the amount of renewable energy production (biomass/biofuels, CHP/ hybrid units, all in percentage units up to 2017);
- 6th Nov. 2008 – Ordinance of Ministry of the Infrastructure (MI) on calculation methodology of the energy consumption characteristics for dwellings and premises. The main part of this ordinance is quoted to certificate documentation;
- 6th Nov. 2008 - Ordinance of MI on specification the scope and form of construction design (HVAC system analysis, study of the renewable energy use for building area higher than1000m^2);
- 6th Nov. – Ordinance of MI on the technical conditions for buildings and their localization;
- Ordinance of the Ministry of Economy on the Electricity Purchase Obligation: This Ordinance stipulates that power utilities had to purchase 2.4% of the electricity from renewable sources in 2001. This percentage will be gradually increased up to 7.5% in 2010.

Apart of its on the Council of Ministers (17th June 2008) was adopted the draft act amending the act on the corporations of architects, building engineers and town-planners, and the Construction Law, submitted by the Minister of Infrastructure. Architects, town-planners and building engineers from EU Member Countries will be allowed to run business activities in Poland on the same conditions as Polish citizens. These regulations are in accordance both to the EU standards and directives, and the actual Construction Law, Environmental Protection and Energy-Save legislation acts in Poland.

EPBD implementation

Calculation method

As was mentioned, an Ordinance of Ministry of the Infrastructure (6th Nov.2008, Dz.U., No. 201), has formally introduced the calculation methodology of energy consumption characteristics for dwellings and premises. Other important regulations are still in the recent progress, but a status of EPBD implementation in Poland is still disappointing.

Energy performance requirements

The Energy Performance Certificates (EPCs) are required for the all new constructions and for the sale or rent buildings. Also, when in result of rebuilding or repair, the energy characteristics of building have changed. It does not apply these regulations only for buildings:

- subjecting regulation on protection of antique,
- used as places of cult and for religious activity,
- assigned for use in time no longer than 2 years,
- non-existing, used in agriculture,
- industrial and economic having request for energy no greater than 50 kWh/m^2 per year,
- assigned for use less than 4 months in a year,
- free-standing with useful area below 50 m^2.

Requirements for new buildings

The new requirements are the subject of being amended Ordinance of Ministry of Infrastructure from 12th April 2002 on the Technical Requirements to be fulfilled by buildings and their localisation. These requirements are on following type: on maximum permissible insulation level, infiltration coefficients for windows and doors, and area of transparent elements. The levels of requirements are same regardless of building functions and types (dwellings, office buildings schools, etc.). The basic requirements are as follows:

- Maximum U-value; apartment buildings walls 0.30-0.40, roofs 0.25, windows 1.7-1.9, other buildings – walls 0.40, roofs 0.25, windows 1.7-1.8;
- Infiltration coefficient less than 0.3 $m^3/m^2daPa^{2/3}$ for windows and balcony doors.

The energy rank is not regulated it is a result of application of specific solutions fulfilling primary (listed above) requirements. After the amendment of Ordinance about the scope and form of building design, every design that will be a basis for obtaining building permit must be accompanied by – filled by designer - the table confirming compliance of fulfillment of energy requirements according to building technical regulations. Upon issuing building permit, and permit for building operation, the authorities in Poland are not verifying the design; they collect and check only the completeness of all documents and their compliance with spatial regulations. Due to energy assessment and certificate, the verification of building design vs. the constructed object will be performed before operational permit.

It should be added that requirements for the existing, modernized or extended buildings will be same as for the new ones. From 1st January 2009 new buildings as well as the modernized, rented and sold should pose energy certificate.

Energy performance certificates

Implementation of Article 7 requiring Energy Performance Certificates (EPCs) will be phased in during 2009: by 1st January, EPCs are required on construction for all dwellings. In May 2008 two first buildings in Poland obtained the EPC documents – in Laski near Warsaw and in city Zamość (the primary school SP No.6, shown below).

Figure XIII.ix - School SP No.6 in Zamość (left) and the Center for Blind Children in Laski (right)

It subjects buildings thermo-modernization and the energy audit according to the previously formulated rules (the AC needs no included before May 2008). The resulting energy demand parameter after the modernization of these objects is rather low - in these two cases energy performance parameter (EP) is close to 200 kWh/m^2a (falling from class "E" to "C" at the label range). Their final energy consumption has falling down up to 40% of the initial state.

Inspection of systems

To satisfy Article 9, by 4th January 2009, first inspection of all existing air-conditioning systems over 250kW will have taken place, especially for problem of leakage losses and use of old refrigerants. All remaining AC systems over 12kW will have been inspected by January 2011. Inspection of boilers and AC units is covered in the fore mentioned Acts and it is planned to be mandatory and in power from 1st January 2009.

Case study 1: Low energy homes

Local authorities in Poland invest in the new technologies which save primary energy resources and protect the natural environment. Since 1999 the most part of stocks of the residential cooperatives and municipal building resources has been thermo-modernized. Modern, low-energy home initiatives allowed developing advanced projects (see, table XIII.i) based on the progress in area of "*passive house*" technologies.

Parameter	Type of the construction		
	"Lipinski Passive House"	*"Warm House 160"*	*"Standard Model 160"*
Net useful area , m^2	154.2	154.2	154.2
Energy effectiveness EF, kWh/m^2a	13.5	44.7	90
Final costs, thousand € (at tax: 3.8PLN/€)	~ 111	87.9	84.7
Unit cost per $1m^2$ of net area, €/m^2	680	540	500
Total cost difference comparing to "Standard Model", %			
	↑ 36%	↑ 8%	0%
Relative heating costs in comparison to actual Polish data (~ 120 kWh/m^2a)			
	11.4%	37.3%	83.3%

Table XIII.i - Improved performance homes in Poland

The first “*passive houses*” are constructed in Poland since 2007. At the end of the year 2008, complete data on the construction and performance of single-family house in Smoleń (near Wrocław) have been published.

“Lipiński Passive House”

The construction of “Lipiński Passive House” shown in the Figure XIII.x has been recently finished.
The building contains the following environmental features:

- External walls: 2-layered sand-calcareous brick elements (24 cm + 20 cm) and foamed polystyrene „Platinum Plus”: U_0 = 0.147 W/m^{2}K, Relius”, plaster external/internal: BASF;
- Carrying internal walls: cellular concrete “Ytong” (24 cm) and fibrous-gypsum plates for partition walls:
- Roofing tile: “Brass” (concrete based), all floors and roofs insulated by 10-20 cm “Platinium Plus”
- Windows: “*Termo PCV*” (“M&S”), U_0 = 1,0 – 1.1 W/m^{2}K (window panels) or “*SUPER Termo”*(0.88 W/m^{2}K), similar for doors U_0 = 1.1 W/m^{2}K;
- Timber floor with the 35 cm wood fibre insulation, placed on the rib-and-slab floor;
- Heating system: condensing boiler “*Vitodens 200*” with “*Purmo*” radiators, and flat solar collectors “*Viessmann*” for hot water demands;
- Mechanical ventilation with the heat recuperation system, including the ground heat exchanger for cooling and warming atmospheric air “*AWADUKT Thermo*” (REHAU).

During summer season, the boilers are turned off, with hot water provided solely by the solar collectors. It is to easy compare the investment and operating costs of this house and their parameters to typical Polish construction market offers. The unit cost of maintenance and energy supply demands are close to 11-12% of the typical reference house (see, Table XIII.i). At the actual economy trends in Poland, whilst the systematic growth of energy taxes and fuel prices are observed, the pay-back period will be less than 15 years (using natural gas for the heating).

a)

b)

Figure XIII.x - Lipiński passive house – view and the 1st floor plan

Decision making

The passive house idea was developed as a partnership project between Lipiński Architectonic Office, BASF, “Termo Organika”, and other companies, including the central agencies (NAPE, ITB). All the partners provided a share of the certified materials and technology support. “REHAU” provided the development expertise and the Lipiński Office the project management.

Cost analysis

The cost of the house construction at € 680/m^2 is relatively low for buildings of this type, especially in comparison to the many European countries (EU-15).

An original version of natural gas central heating system can be improved by using the hydronic heat pump and the low-temperature floor-heating system (38- 40°C). The cost of such unit is really expensive (mainly by ground source heat exchanger), and final economy is not very attractive for Polish customers.

Case study 2: City studies - Rzeszów

City

Rzeszów is a city in a south-eastern part of Poland. It is located on both sides of Wisłok river. Rzeszów is also a capital of the Podkarpackie Voivodeship. Rzeszów is served by an international airport, is a member of Eurocities, and is home to number company headquarters, 5 universities and 2 foreign consulates. At the June 2008 Polish official Census, the total population of Rzeszów was 171,330 inhabitants. The total area of Rzeszów is 91.5 km^2 (97.6 km^2 since the beginning of 2009). It has a population density of 1880 inhabitants per square kilometer. The city and region belong to the group of most intensive developing parts of Poland based on the EU founds (aeronautical and chemical industry, agriculture and transport, tourism and education).

Cogeneration

Cogeneration (CHP) is based on the technology for electric energy and heat generation on the basis of the common source of fuel. Experiences of the energy sector confirm that generating electric and heat energy in the combined-cycle, utilizing gas fuel during the process, is the most reasonable and effective solution for achieving high energy efficiency in comparison with the alternative technologies separating generation of electric energy in power plants and heat in heating plants.

Gas-steam power unit in Rzeszów

In 2002 the Rzeszow Power Heat Plant (EC-Elektrociepłownia Rzeszów) finished construction new combined gas-steam power (CHP) unit. Total power capacity of the plant achieved 101 MW$_e$ and 332 MW$_{th}$. The technological structure of gas-steam power (GSP) unit is shown in Figure XIII.xi.

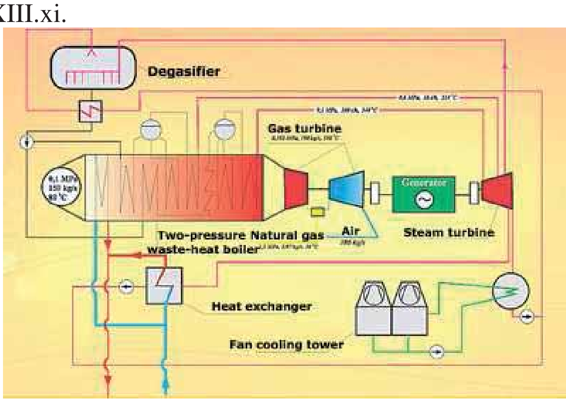

Figure XIII.xi - GSP technological structure

Gas and steam power unit (GSP) constitutes the combined system (CHP), which consists of:

- gas turbo-set based on Siemens V64.3A turbine for the electric power generation,
- heat recovery steam generator (HRSG), utilizing flue-gas enthalpy from the gas turbine to produce steam and lattice hot water,
- bleeder-condensing steam turbine to production of useful heat supply and electric energy in the combined-cycle.

Performance data of GPS unit in the EC-Rzeszów heat and power plant are shown in the Table XIII.ii.

Parameter	Unit	Heating season	Summer season	Annual
Gas consumption	kg/s	3,97	3,75	
Fuel chemical energy flux	MJ/s	193,6	184,5	
Thermal power	MJ/s	76,30	18,00	
Electric power	MW	93,90	92,04	
Flue gas flux	kg/s	190,0	183,0	
Electric effic.	%	48,51	49,89	49,04
Fuel utilization	%	87,93	59,64	77,05

Table XIII.ii - Major GPS unit utilisation indicators

The power plant meets almost all needs for applying environmental friendly technologies (see, Figure XIII.xii).

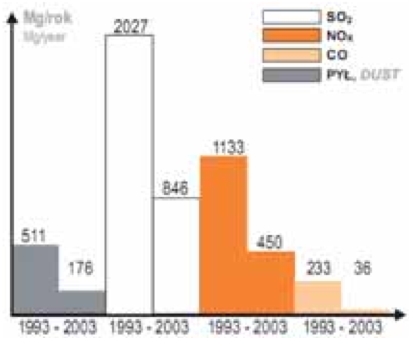

Figure XIII.xii - Change of emissions from EC-Rzeszów

The concern for environment is demonstrated by the way the waste, generated in the plant, is managed in conformity with regulations, paying special attention to dangerous wastes. Rzeszów Cogeneration Power Plant (CPP) has been granted permission to generate 56 wastes, including 17 types of dangerous wastes. The wastes generated in the largest quantity in this CCP are:

- ash, cinders and cinder mix from wet waste disposal
- iron and steel.

The plant is also engaged in recycling the cinders and sediments from Water Treatment Station. Passing each type of waste on a new recipient takes place in conformity with regulations and on the basis of an arrangement with a recipient and a filled-in charter for waste disposal (see, Table XIII.iii).

Ashes	Unit	Year			
		‘97	‘99	’01	‘03
Produced	Gg	24	16.9	13.5	6.0
Utilised	Gg	18.3	23.1	28.7	33.6
Stored& used	Gg	-	6.2	15.2	27.6

Table XIII.iii - Furnace wastes use from EC-Rzeszow

Ashes from CPP are utilized mainly as an addition to production of building elements.

SCHP systems in Rzeszów

Small combined heat power (SCHP) systems are also used in others enterprises in Rzeszów, as for example waste-water treatment and municipal gas works. These companies use small cogeneration units based on internal combustion engines (gas engines).

Waste-water treatment plant “Załęże” (WWTP) has new two co-generation units MB 3042L1. Each unit produces 345kW$_e$ power and 531kW$_{th}$ of heat. The new SCHP system replaced older one which used to work in the WWTP in Rzeszów from 2000 to 2003. The system is fed on biogas like the previous ones. The biogas is a product of the sewage fermentations.

Technological structure of this unit is shown below.

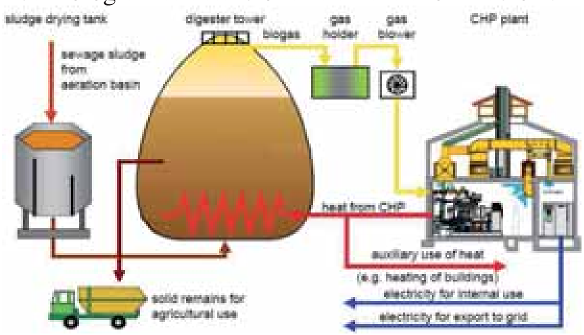

Figure XIII.xiii - Schema of cogeneration in the ST Plant

A practical effect of modernization of the system is a considerable increase in the produced heat and electric power. The produced amount of heat and power entirely cover the heating needs of the WWTP and the produced electric power covers the electric needs in 49 %. Other characteristics of system:

- water temperature in/out – 90/70 ºC,
- connecting of energetic line,
- safe gas line,
- emergency cooling system,
- air conditioning system.

The first tri-generation system (CHCP) in Poland was constructed for the municipal gas works in Rzeszów. It bases on one gas engine unit ME 3066D1**,** which is fed on natural gas. The unit generates 116kW$_e$ power, 198kW$_{th}$ heat and 122 kW$_c$ of the cold. Other characteristics of system:

- water temperature in/out – 100/80 ºC,
- temperature of chilling water – 7 ºC.

Decision making

GSP project was funded by EC-Rzeszów and co-funded by *“Ekofundusz”* foundation (10% of the all investment cost). Also it was obtained loan from the *National Fund for Environmental Protection and Water Management* (NFOŚiGW) and *BOŚ* Bank. Investor of SCHP systems in Rzeszów was *Polskie Elektrownie Gazowe*, owned by *Polish Oil Minning and Gas Engineering S.A.*(PGNiG) and *Pumped Storage Power Plants Co.* (PGE). Both units were constructed and supplied by *Applied Electronics Centre* (CES).

Cost analysis

The total cost of the GSP project amounted to 300 million PLN (zlotys). Investment cost should pay back in 10 years. Let’s now compare two systems to see SCHP profits (energy and gas bills adopted by estimation):

- First, conventional system based on natural gas boiler to get thermal energy (electric power from separate power plant).
    - Yearly costs of electric power: 345 kWe·24h ·50·7 days ·0,23 PLN = 690,000 PLN
    - Yearly costs of thermal energy:
        - For assumed 90% gas utilization efficiency, 1 m3 of natural gas equals to 10 kWth, and 531 kWth/0,9/10 =

58,8 m3/h; therefore 58,8 m3 · 24·50 ·7 days · 1,075 PLN = 531,000 PLN,
  - Yearly costs of gas boiler service exploitation is approximately equal to 12,000 PLN.
  - Total costs (in thousands PLN): (690 + 531 + 12) ·103 = 1,233,000 PLN per annum.
- Second case -CCHP system based on MB 3042L1 unit. Natural gas consumption of unit is 98,7 m3/hr.
  - Yearly costs of demand to gas: 98,7m3 ·24·50·7days ·1,075 PLN = 891,000 PLN,
  - Yearly costs of unit exploitation: 60,000 PLN,
  - Total costs: 891,000 + 60,000 = 951,000 PLN per annum.
  - Annual savings: 1,233,000 – 951,000 = 282,000 PLN per annum.
  - Purchase cost of CCHP unit: 1,300,000 PLN.

In this case the simple pay back time will be 4 years and 7 months. After this time, every next year of the investment brings savings only.

Carbon analysis

Realization of GSP and SCPH projects has the significant ecological effect. CO_2 emissions have decreased about 146,000 tonnes per year. Values of CO_2 emission index for different utilization systems are shown in the Figure XIII.xiv.

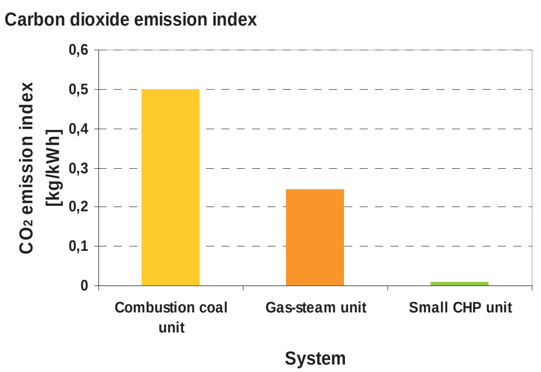

Figure XIII.xiv - CO_2 emission index for different systems

Urban case study 3: Clean Transport Systems in Rzeszów

The air pollution in the city caused by public transport is a problem which many cities in Poland are facing. Reducing emissions of the gases has become a priority target for local authorities. Communication enterprise in city Rzeszów (*MPK Rzeszów*), as one of the first in a country introduced ecological buses fueled by the natural gas (CNG). The city public transport operates 49 lines and 196 bus fleet including night and airport buses (Figure XIII.xv).

Figure XIII.xv - Rzeszow - map of public transportation net

This system will be significantly improved in the nearest time based on the ERD Found (€85 mln). It will be done by modernization of arterial streets and urban transport systems and the implementation of adaptive SCATS traffic management. The SCATS monitoring system with GPS signals and camera registration on the main city arteries allow to active control of the road traffic. In 2001, the European Commission indicated natural gas, together with biofuels and hydrogen as the most important alternative fuel for vehicles.

CNG city buses

The total number of buses in MPK Rzeszów is almost 200 vehicles. Since 2005 the transport enterprise *MPK-Rzeszów* introduced 40 new CNG buses "*Jelcz M120/125M*" and "*Solaris-Urbino 12*", matching EEV emission standards. The full list of all CNG buses and their main specifications are shown in the Table XIII.iv.

Model	Engine power [kW]	Engine Capacity [dm^3]	Gas tanks [m^3]	Range [km]
“Jelcz” 120M/1	152	11,1	165	350
“Jelcz” 120M/4	180	11,97	190	350
“Jelcz” 125M/4	185	11,97	250	430
“Solaris” Urbino12	200	7,8	250	500

Table XIII.iv - CNG buses specification in MPK-Rzeszów

Additionally a fast fuelling station has been opened in the bus depot. The CNG buses cause low noise emissions and provide better riding comfort. CNG bus is expected to be 30% cheaper compared to conventional diesel ones. Natural gas is a natural fossil fuel, which except for the compression to 20 - 25 MPa, does not require any additional processing and investment. The gas compressing in automotive power unit is necessary because methane has too small energy density at the atmospheric pressure to obtain a satisfactory energy. Bus engines powered by CNG are natural gas versions of diesel engines. Adaptation of diesel engine to the gas engine involves re-design supply system, installation of the ignition system and control system, increase expenditure for the cooling and rebuilding the combustion chamber.

Performance criteria

The development of CNG technology infrastructure in Rzeszów depends on both matters related to the purchase of city buses as well as the development of CNG refueling stations.

- In 2003 two city buses Jelcz 120 were prepared to be supplied by CNG.
- In 2004 they purchased 5 buses Jelcz 125 M/4/ CNG. This year also expanded CNG station, which increased its capacity from 60 to 300 m3 per hour.
- In 2005 the enterprise purchased another 5 buses Jelcz 125 M/4/CNG.
- 2006 was the year of the largest purchases in MPK-Rzeszów. It purchased 1 bus Jelcz 125 M/4/ CNG, 9 buses Solaris Urbino 12 CNG and 10 buses Jelcz 120M/4/CNG. There was also an increase in the capacity of CNG refueling station to 900 m3/hr.
- Last 8 buses Jelcz 121 M/4/CNG was purchased in 2007. Refueling station increased capacity to 1200 m3/hr. The station does not only serve needs of the MPK fleet but it is also open to the public.

Decision making

CNG technology was developed as a partnership project between *MPK-Rzeszów*, management of the city, Gas Companies belonging to PGNiG, vehicle producers and funding institutions as “*Ecofund*” and NFOŚiGW.

Cost analysis

Total investment cost, which concerned the purchase of all 40 city buses fed by CNG was 27,500,000 PLN. The *Ecofund* grant helped to finance the purchase in the amount of 100,000 PLN per one bus (14.5 % of the cost). Pay back of the investment cost depends primarily on a difference in fuel prices and excise tax. Currently, for each 100 km, the *MPK-Rzeszów* can save up to 20 PLN, using CNG instead of the diesel oil. For example, a yearly comparison of gas and oil costs for *MPK-Rzeszów* in 2006 is shown in the Figure XIII.xvi.

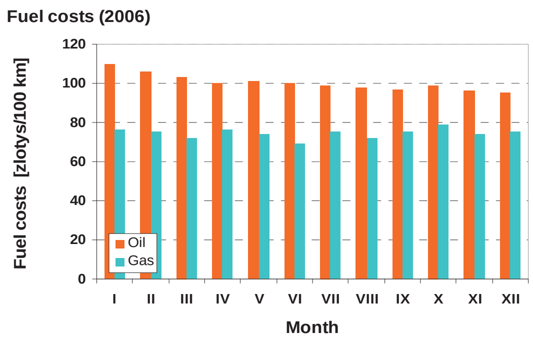

Figure XIII.xvi - Comparison of fuel costs in 2006

Carbon analysis

CNG improves the ecological face of the city. It is important that a significant reduction in emissions of harmful substances in comparison with the classic buses, reaches over 85%, including CO_2 emissions. All CNG buses met actual *Euro 5* standards. After 240,000 km, an amount of CO_2 emitted by CNG-powered bus compared with the conventional one is definitively lower. The yearly emissions of carbon dioxide from city buses in Rzeszów fell down by almost 330 tonnes.

City case study 4: Elevated city rail

Rzeszów has recently been inspired by the visionary promise and benefits of "MISTER" (*Metropolitan Individual System of Transportation on an Elevated Rail*), project of Polish engineer – O. Mikosza. The City's Mayor and Council are currently considering best ways to provide funding for the pilot system.

MISTER

MISTER is a new, innovative public transportation system for cities, where small, fully automatic, driverless vehicles are traveling independently suspended under an overhead network of light truss rails. All trips are only on demand and individual, therefore absolutely safe. They are taking place from start to any destination point without stopping. Stops are off-line; therefore they do not obstruct the traffic on main lines. *MISTER* system consists of four main elements:

- aerial infrastructure - columns supporting light guide way structure,
- small, 1-5 person automatic vehicles, electrically powered from external traction,
- small off-line stops, which therefore do not block any main line traffic,
- integrated computer control systems.

Figure XIII.xvii - Prototype of MISTER Gondola and system visualization concept

Prototype of *MISTER* Gondola was presented at the first time in 2007. Construction of gondola and *MISTER* infrastructure visualization are shown in the Figure XIII.xvii.

Cost analysis

Contrary to all other public city transport systems, which are subsidized, *MISTER* will be very profitable, despite the same level of ticket pricing, or even with some reductions. The reasons for this profit are major reduction (some 5-10 times) of:

- energy consumption per payload,
- staffing,
- service and maintenance.

Total costs (including rolling stock) amount 1,000,000 to 2,000,000 PLN per kilometer. Annual net income is about 4,000,000 to 10,000,000 PLN per kilometer. Energy cost per passenger-kilometer is 0.02 PLN, and the total cost of exploitation per passenger-kilometer are close to 0.20 PLN.

City case study 5: Energy from the sun

Solar energy has more and more new followers in local government and investors. Heat from solar thermal collectors is used in Poland mainly in public or domestic hot water systems. Presently, systems based on solar energy, which support warming up the water for swimming pools are applied in many sport objects.

Swimming pools

There are three swimming pools which make the most energy from the sun in Rzeszów. All objects stand at Lower Secondary Schools and are used by pupils as well as individual clients. These swimming pools, located in large residential neighborhoods, and city authorities are very concerned to promote solar energy, especially among young people who see that its operation. In this way they learn ecology, and in the future, wish to use it. Quantity and total areas of collectors installed are shown in Table XIII.v.

Object name	Panels No.	Total area
Muszelka	56	102,48 m^2
Karpik	56	102,48 m^2
Delfin	60	109,80 m^2

TableXIII.v - Solar collectors at the swimming pools

The main parameters of a single solar panel are:

- type – flat plate,
- height/width/length – 89/1037/2018 mm,
- weight – 38 kg,
- lightweight aluminum frame,
- absorber area – 1,83 m2,
- absorber coatings – black chrome,
- low iron tempered glass cover,
- optical efficiency – 81,2%.

Collectors are set on the building roofs, facing to the south. Required water temperature in the swimming pool is nearly 28°C. Heating water system needs heat exchanger (JAD type for swimming pools), which separates solar system with antifreeze liquid (propylene glycol solution) from water system with the filter, pump and swimming pool. When the glycol temperature is 70/35 °C, and the receipt water temperature 10/55 °C, system provides about 50 kW_{th} of heat.

Solar panels cover almost 100% of the required heat to warm water in closed swimming pools at Polish climatic conditions between April and September. During winter season the water is heated from conventional sources (local heat plant or gas boiler).

Decision making

Solar systems for swimming pools project were developed with help of the school and city authorities and financing institutions. Installation works for swimming pools "*Karpik*" and "*Muszelka*" were completed at the end of 2007. Solar panels have been installed in "*Delfin*" swimming pool in Nov. 2008).

Cost analysis

Each object received funding amounting to 300,000 PLN, but 75,000 PLN of that cost was the city's own resources. The rest (225,000 PLN) comes from the funds (the most: 102,220 PLN – *Ecofund*, and 40,500 PLN – *National Fund*).

Carbon analysis

The solar radiation reaching the ground in Rzeszów is about 1050 kWh_{th}/m^2 per year. Yearly average efficiency of solar collectors (inclined to 45º) is close to 50%. Useful energy that can be obtained is 525 kWh_{th} for each square meter of absorber area. Thermal energy get by the solar panels is estimated between 53,800 to 57,600 kWh_{th} per year for these swimming pools. Summary it gives over 165,200 kWh_{th} per annum of thermal "clean" energy.

Other systems

Within the 2005 – 2006 year in Rzeszów were installed other five large hot water heating systems, four systems in nurseries and one in the welfare house. Short characteristics of the selected systems are given bellow:

- Nursery "Puchatek" in Rzeszów has installed 35 solar panels. Total absorber area is 63.7 m^2 and useful energy of solar heating system 31,500 kWh_{th} per year. Other nurseries in Rzeszów have installed six solar panels each, which total absorbers area 10.92 m^2. Thermal useful energy amount is estimated as 5,400 kWh_{th} per year for one nursery.

- The largest installation in Rzeszów, including 28 solar collectors, has been made in the Welfare House (see Figure XIII.xviii). Total active area is 67.48 m^2, and an estimated thermal power of the system 58 kW_{th}.

Figure XIII.xviii - Solar installation at Welfare House roof

Key points

Generally thermal solar energy is used to warm up the water, which is used in many ways. Swimming pools and domestic systems are only examples of use. Solar installations are working well in the period from spring to autumn. However, keep in mind that the sunny weather is unpredictable in Poland and therefore it is necessary to install additional conventional sources of energy. Solar energy is still relatively expensive and though institutions and individuals are interested in using it the installation stills need financial support to be interesting in terms of return on investment.

Other initiatives

At the beginning of January 2009 in the Rzeszów City Department, application had been made for permission for the construction of hydroelectric power station at the dam on the Wisłok River. Some new investments have been activated to use the local resources of renewable energy (wind farm in Wróblik Szlachecki, GSHP installations in the curia Przemyśl and Polish Radio Rzeszów, production of biofuels).

Other important initiatives have been initiated by Podkarpacka Agency of Energy Management (PAE). PAE is a first Polish regional agency created in 2006 with the financial support of European Commission through "*Intelligent Energy – Europe*" programme [8]. The aim of agency is to promote renewable energy sources, energy efficiency, sustainable transport and knowledge on climate changes issues. They prepare better conditions for renewable energy investments in the region and to assist public and private bodies as well as citizens on energy efficiency and RES issues.

Observations and conclusions

Some not-solved questions of an implementation the actual EPBD rules in Polish construction sector are:

- Not completed and well prepared procedures of building certification (methodology based on 13790EU Standard /2006 year).
- Not actual data base on construction material properties and reference technologies.
- Not well developed training system (no precise conditions for survey expert qualifications, lack of final exam evaluation methods and not easy access to standards).
- No local expert centers and selected software for valuable test evaluation.
- Lack of formal cancellation procedures for the decisions (Ministry <-> customer or developer).
- Building certificates are based only on the design conditions (statistical data – not on real occupancy data during building exploitation).

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XIV Portugal

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National context

Portugal comprises three territories; the Mainland, and the Atlantic archipelagos of Azores and Madeira, with regional parliaments and autonomous regional governments. As far as energy and environment are concerned, there are not significant differences in the objectives, policies and regulatory and fiscal instruments adopted by the national and the regional governments. They are all firmly committed to reduce current levels of CO_2 emissions. And some recent achievements, particularly on the supply side of the energy market, seem to confirm the ambition of the current political discourse.

In a country condemned to import oil and gas and with scarce coal resources, nuclear power has been, and still is, out of the energy portfolio. On the opposite, renewable energies are on the rise and are already responsible for 42% of the country's electricity production, one of the highest percentages among European countries.

The world's largest photovoltaic plant is located in Portugal, in the southern region of Alentejo. The importance of this investment contrasts with the still modest use of solar energy in domestic water heating by most Portuguese households. However, this is likely to change in the near future with the new building regulations (2006). All new buildings have to install solar systems. In addition, a recent government initiative launched an ambitious campaign to generalize the use of solar panels in existing buildings throughout the country, through attractive financial incentives, tax reductions and subsidies.

Climate

Portugal mainland has a mild climate, with Atlantic characteristics in the North and Mediterranean characteristics in the South. The annual number of hours of sunshine varies from 2000 in the north to 3000 hours in the south. The average yearly temperature is 15ºC. Average monthly temperatures range from 20ºC in the warmest month to 10ºC in the coldest month. Maximum and minimum temperatures seldom rise above 35ºC or below 0ºC, except in mountain areas where snow may occur in the coldest months of the winter.

The annual average relative humidity countrywide is close to 75% with higher values of 85% on the coast and lower levels of 65% in the interior. Precipitation varies widely from north to south. In the north can reach 3000mm per year and above, one of the highest in Europe, whereas in the south seldom exceeds 500mm. In both cases is mostly concentrated in the winter months. Summers are usually dry and slightly to moderately windy, particularly along the west coastline, where the prevailing wind is from the northwest.

For regulation purposes, the territory is divided into three winter climatic zones and three summer climatic zones. Figure xx presents the distribution of these climatic zones.

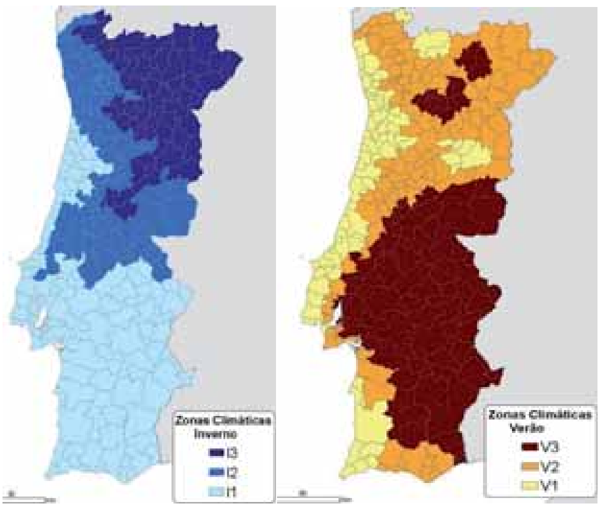

Figure XIV.i - Portuguese climatic zones (left, for winter; right, for summer)

The winter climatic zones are defined taking into account the number of Degrees-days of each administrative division, considering a comfort indoor temperature of 20ºC. As an example of locations belonging to different winter climatic zones, we can mention Lisbon, in I1 winter zone, with 1190ºC.days; Oporto, in I2 winter zone, with 1610 ºC.days and Bragança, in I3 winter zone, with 2850 ºC.days. For the summer, the definition of the climatic zones is based on the External Design Temperature, which means the external temperature that is not exceeded for more than 2.5% of the summer time period. As examples we can mention: Oporto, in V1 summer zone, with an external design temperature of 30ºC; Lisbon, in V2 summer zone, with an external design temperature of 32ºC and Évora, in V3 summer zone, with an external design temperature of 35ºC.

Demographics

According to the National Institute of Statistics, Portugal had 10.6 million inhabitants in 2007. With a total area of approximately 92000km^2 the country's population density is slightly above 115 inhabitants per square kilometre. Most of the Portuguese population is concentrated along the coastline and, in particular, in the two metropolitan areas of Lisbon and Oporto with, approximately, 2.5 and 1.5 million inhabitants, respectively.

Population has been relatively stable in the last couple of years due to immigration flows that have been able to offset the decline in birth rates, already slightly below death rates (9.7 and 9.8 ‰, respectively). To prevent population shrinkage in the next decades, a significant increase in birth rates has to occur or past immigration flows have to be kept. Both scenarios strongly depend on the future social and economic performance of the country.

Carbon dioxide emissions

Under the Kyoto Protocol, the EU-15 took on a common commitment to reduce greenhouse gas emissions by 8 % until 2008 - 2012 compared to emissions in the 'base year' (for CO_2 the base year is 1990). In this framework Portugal was allowed to an increase of 27% (EEA, 2009).

In Portugal, total greenhouse gas emissions (GHG) excluding LULUCF, expressed in million tonnes of CO_2 equivalent, raised from 60.1 million tonnes in the reference year to 81.8 million tonnes in 2007, which means an increase of 36.1%, already slightly above the Kyoto's benchmark for Portugal. However there was a reduction of 3.4% between 2006 and 2007. The increase that took place till 2006 was in part a result of the rapid increase in energy consumption observed in Portugal from 1995 to 2000, at an annual rate of 5.3%, well above the then EU-27 average of 0.8%. This increase in energy consumption slowed down from 2000 to 2005, to 1.3% in line with the EU-27 average of 1.1% (MEI, 2008). In any case, energy consumption is still showing signs of a slight upward trend.

In the context of the other European countries, GHG emissions in Portugal are not high. Portugal is still one of the EU-27 with lower greenhouse gas emissions.

Energy in Portugal

Portugal imports most of its primary energy. In 2005, around 87.5% of the energy consumed in the country had an external origin. For that year, primary energy consumption was composed by 59% of oil consumption, 14% of natural gas, 13% of coal and 13% of renewable sources. The importance of renewable sources for electricity production has been rapidly increasing. The government's target to achieve, by 2010, 45% of electricity production based on renewable sources proved to be realistic (the corresponding figure for 2008 already was 42%).

In 2005, the final energy consumption in Portugal was 1.84 toe per capita. The distribution of final energy consumption among the different sectors was as follows: 28.4% in industry; 35.4% in the transport sector; 16.5% in residential buildings; 13% in non-residential buildings and 6.7% in other sectors (like agriculture, fisheries, etc).

CO2 emission policy measures

The first version of the National Climate Change Programme (PNAC) was adopted in 2000 and, since then has had several updates. The 2006 version of PNAC includes the following sectors of the economy with an impact on GHG emissions: Energy (demand and supply, including the subsectors Transport, Residential and Services, and Industry), Agriculture and Livestock, Forestry and Waste (IA, 2006). In the context of PNAC, Portugal implemented a wide range of policies and measures covering all these sectors of the economy. In fact, PNAC constitutes the Government's framework plan that supports the accomplishment of the Kyoto Protocol by the Portuguese State.

Building regulations

Portugal adopted EU building directives in its Building Regulations. These regulations have been recently reformed, especially in terms of energy requirements for buildings.

For new buildings and major renovations, the proof of compliance with the regulations that insure the transposition of the EPBD must be made when requesting the building permit and after completion of the building. The control is the responsibility of the Municipality where the building is located, based on a Declaration of Compliance with the national building regulations issued by a qualified expert registered in the SCE (System for Energy and Indoor Air Quality Certification of Buildings).

EPBD implementation

In Portugal, the implementation of the EPBD is the overall responsibility of the Ministry for the Economy and Innovation together with the Ministry for the Environment, Spatial Planning and Regional Development. The direct responsibility for the contents of thermal regulations belongs to the Ministry of Public Works, who updated it under request from the Ministry for the Economy and Innovation. The government is, therefore, responsible for the preparation and approval of legislation which is nationwide and the regional and the local authorities are responsible for its implementation and control.

On 4 April 2006, the Portuguese Official Journal published three Decrees that, together, constitute the transposition of the EPBD into national law:

- Law-Decree 78/2006 – It creates and defines the operational rules for the System for Energy and Indoor Air Quality Certification of Buildings (SCE) – EPBD articles 7 and 10;
- Law-Decree 79/2006 – It establishes the new revision of the Regulations for HVAC Systems, including requirements for regular inspection of boilers and air-conditioners (RSECE) – EPBD articles 8 and 9. This decree revises and substitutes Law-Decree 118/1998;
- Law-Decree 80/2006 – It establishes the new revision of the Thermal Regulations for Buildings (RCCTE) – EPBD articles 3 to 6. This decree revises and substitutes Law-Decree 40/1990.

Calculation method

The calculation methodologies are included in the Thermal Regulations for Buildings (Law-Decree 80/2006) and in the Regulations for HVAC Systems (Law-Decree 79/2006) and are mandatory. Both regulations have a national scope. Carbon emission is not specifically mentioned in these methodologies but its calculation is necessary for the complete fulfilment of the certificate.

Energy performance requirements

The energy performance requirements are applied to each residential and non-residential autonomous part of the building, which means the units, inside a building, that have an individual measurement and record of energy consumption and which can be sold or transmitted autonomously. In a multifamily building, for instance, each dwelling must comply with energy performance requirements.

Some exemptions are foreseen like: the buildings or parts of buildings, new or renovated that, because of their type of use, are meant to be left frequently opened to the exterior; religious buildings; factories (only the buildings directly related with the production process); garages; warehouses; non-residential agriculture buildings; historic buildings and military buildings.

In Law-Decree 80/2006, for residential buildings and small non-residential buildings with HVAC systems, if any, with a power lower than 25 kW, limits are established for heating, cooling and hot water energy consumption.

In Law-Decree 79/2006, for non-residential buildings and residential buildings with HVAC systems with a power higher than 25 kW, energy consumption for lighting is also considered.

i) For new buildings
The energy performance requirements are mandatory for the request of building permits and for use. The type and level of requirements are function of the type of building (dwellings, office buildings, schools, etc.) and cover mainly:

- Maximum heating and cooling needs per m2 of floor area (residential only);
- Maximum U-values;
- Minimum shading requirements for all windows;
- Minimum requirements for thermal bridges;
- Maximum energy consumption for production of hot water, including mandatory installation of solar water heaters (all buildings);
- Maximum primary energy consumption per m2 of floor area (all buildings);
- Minimum efficiency and quality requirements for heating and cooling components (non-residential buildings).

The use of solar energy is mandatory for the heating of domestic water and the use of other renewable sources of energy is also taken into account in the calculation method in a beneficial way, to incentive their use. The efficiency of equipments is also an important factor in the calculation. The type of energy used influences, obviously, the value of primary energy consumption.

The maximum value of heating needs is established in function of the compactness of the building (a Form Factor is defined as the ratio between the surfaces through where the building loses heat and its interior volume) and the number of Degree-days of the place. The maximum value for cooling needs is a fixed value for each summer climatic zone. The maximum U-values depend on the climatic zone, on the type of construction element and on its position in the building. The minimum requirement for shading depends on the orientation of the window, on the climatic zone and on the thermal inertia of the building.

ii) For existing buildings

The same requirements as for new buildings are also set for major renovations which mean renovations of the building or of the systems that represent a total cost higher than 25% of the whole building value. The renovated building as a whole must comply with regulations. If the operation includes the creation of new areas independent from the rest of the building, they must also comply with the requirements. Minor renovations are not obliged to the energy performance requirements but their compliance is strongly recommended by means of the certification system.

Energy performance certificates

Certification is mandatory, since 1st July 2007, for all new buildings, with a floor area higher than 1000 m^2, requesting a construction or use permit. Since 1st July 2008, all the new buildings are obliged to certification independently of their floor area. Finally, from 1st January 2009 on, certification is fully implemented, both for new and existing buildings.

Until the end of January 2008, there were more than 1500 Energy Certificates registered on a web based central registration system that qualified experts must access and use to issue certificates. This way, a national database of certified buildings is being updated with information that will be useful to monitor progress of different aspects of the implementation of the Directive.

The energy performance certificate includes the classification of the building (classes from G to A^+), the value of its primary energy consumption, in koe/m^2.year, the disaggregation of this value in heating, cooling and hot waters energy consumption, in kWh/m^2.year and CO_2 emissions estimation, in tones per year. It includes also a field for the expert to propose additional energy efficient measures.

Inspection of Systems

Qualified experts are the only people permitted to issue Certificates and carry out inspections. They must be recognized architects or engineers with at least five years experience. In addition, qualified experts must attend recognize courses and pass a demanding national examination.

The National Energy Agency (ADENE) co-ordinates the training of qualified experts and is responsible for the Energy Certification module in all courses (other institutions can organize these courses but they need a previous approval by ADENE) and for the final qualification of experts.

A professional license, valid for 5 years, is issued to qualified experts. They can act on an individual basis or integrated in public or private organisations.

Building case study: Ponte da Pedra Cooperative Housing

Ponte da Pedra is a cooperative housing initiative and came out of an Ideas Competition. It has been developed under controlled costs, approved and subsidized by the National Institute of Housing (INH) and so it can be considered as social housing.

The construction of the buildings replaced an old tannery, improving the quality of the site, since this promotion included also environmental and urban regeneration. It had two phases which have been developed between 1998 and 2007. The second phase of the project represents Portuguese participation in the SHE Project (Sustainable Housing in Europe). The aim of SHE Project was the demonstration of the real feasibility of sustainable housing as far as the economic, the environmental, the social and the cultural issues are concerned using, for that purpose, European cooperative constructions as dissemination pilot projects.

Ponte da Pedra (second phase) was awarded, in February 2007, an Energy Efficiency Prize 2007, in the Category “Public – Private Partnership” by the

Directorate-General for Energy and Transport of the European Commission, on the scope of the Sustainable Energy Europe Campaign 2005-2008. This project had the institutional support of FENACHE (National Federation of Cooperative Housing, F.C.R.L.) and FEUP (Faculty of Engineering of the University of Porto).

The Buildings

Ponte da Pedra is situated in the North of Portugal, in Matosinhos, near Porto. The first phase of the project was composed by 6 residential buildings with a total number of 150 dwellings, educational and cultural equipment placed in the North of the new street and a sports area in the middle of the housing area. The second phase of the project was composed by two residential buildings (101 dwellings) and has also a nursery, a public park with a water mirror and gardens and sidewalks all over the place.

The buildings of the first phase were built in a usual way and without particular features, but with an architectural conception similar to the one of the second phase. The buildings of the second phase, concluded in February 2007, have some building and systems features that didn't exist in the first phase and that really distinguish them from the current construction in Portuguese cooperative houses.

In figure XIV.ii, the site layout of the second phase (buildings 7 and 8) is presented.

Figure XIV.iii shows pictures of the buildings and figure XIV.iv, some construction details. In order to reduce the energy consumption for heating, cooling, hot water and lighting the following main characteristics have been considered:

- Building orientation – it has been optimised in order to benefit of the passive solar potential;
- Envelope Insulation level – low U-values have been assured and thermal bridges have been treated;
- Installation of solar panels on the buildings roofs for the heating of water;
- Use of low consumption lamps and electronic systems in every common areas, turned on by solar cells placed outside;
- Use of movement detectors in main rooms, staircases and corridors;
- Adoption of crossed ventilation inside the dwellings, natural as much as possible, in order to avoid overheating in summer, without needing air-conditioned.

Figure XIV.ii - Site layout (buildings 7 and 8)

Figure XIV.iii - One of the buildings in construction (left); Entrance area of the other building (right)

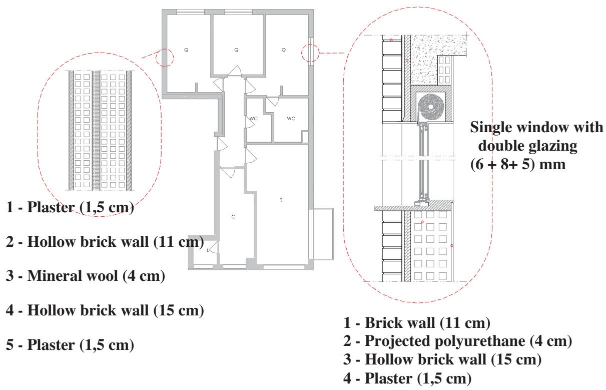

Figure XIV.iv - Some construction details

Management

The real achievement of a low carbon building depends greatly on its users' behaviour. In Ponte da Pedra the users were involved in the decision process and they could acquire an early consciousness of the main challenges. A *User Manual* was prepared that gives the users a code of good practices for the use and maintenance of their building.

Performance evaluation

The objective was to build class A energy efficient buildings. The new Thermal Regulations, already complying with EPBD, were followed even before the date when these regulations came into force. The compliance with the Class A criteria was checked through a specific monitoring programme.

The monitoring survey that was carried out from January 2008 to January 2009 allowed for a detailed evaluation of the buildings. Data for water, gas and electricity consumption were recorded on a regular basis from meter readings in blocks of both phases. These collected data show that there was a significant global reduction in consumption, in the second phase blocks [x]. During the monitoring period the reductions were as follows:

- Water consumption was reduced by 75%;
- Gas and electricity consumption were also significantly reduced (gas also by 75%, electricity by 40%).

Decision-making

The decision making was established in the frame of SHE approach. This means that it has been paid a particular attention to the importance of participation to achieve the involvement of the stakeholders, including cooperative directors, technical staff, authorities and, particularly, cooperative members, the future users of the sustainable dwellings whose commitment with sustainability fully determines the project success.

This commitment with sustainability was embraced by the decision makers adopting some important main criteria that must be mentioned:

- Buildings integration in the local area, respecting natural resources but taking advantage of the local potential;
- Materials selection, taking into consideration durability, low maintenance cost, environmental care and users health;
- The respect for water cycle, reducing and rationalizing the use of this source;
- Waste management during the buildings construction and use, promoting separation for recycling;
- The importance of natural light inside the dwellings, reducing the use of artificial lighting;
- The importance of acoustical insulation, controlling the transmission of noise from outside to inside and from dwelling to dwelling, vertically and horizontally, in order to maximize indoor comfort.

Cost analysis

The total cost of the second phase was of €9,216,160, co-financed by SHE Project. The price for sale was 5% above the traditional cooperative buildings but the promoter expects a payback period as short as 3 to 4 years.

In what concerns operating costs, a comparison between the first phase (traditional buildings) and the second phase (sustainable buildings) is possible if potential consumptions are compared. In Table XIV.i the potential savings are presented, in terms of energy and water consumption. These savings represent significant reductions in operation costs.

Type of consumption	Savings (%)
Hot water (gas)	91
Heating energy (electricity)	54
Cooling energy (electricity)	100
Artificial Lighting in dwellings (electricity)	61
Artificial Lighting in collective spaces (electricity)	69
Water consumption in dwellings	40
Water consumption in gardens	60

Table XIV.i - Potential savings in the second phase, in comparison to the first phase, in terms of energy and water consumption

Carbon analysis

From phase 1 to phase 2, buildings changed from energy efficiency class B^- to class A, with an estimated potential reduction of CO_2 emissions of 60%.

Key points

We can highlight some important points of the Ponte da Pedra project:

- The fact that it is a case of social housing with strict cost controls;
- The cooperative members participation, their commitment with sustainability;
- The global approach, following SHE project criteria;
- The fact that an overall task of monitoring was carried out, allowing the characterisation of the real consequences of the project choices and, therefore, the detection of errors or faults that must be avoided in future projects and the identification of ways of improvement.

Planning legislation

The Portuguese planning system is a plan-led system in which the municipal level plays the most important and operational role. Development control powers are a responsibility of local planning departments. All municipalities have to prepare a Municipal Master Plan (the PDM) covering the entire municipal territory, i.e. including urban and rural areas. The PDM is a structure plan that is expected to work as a framework to guide the preparation and implementation of lower levels plans, such as Urban Development Plans (PU) and Detailed Plans (PP).

The Portuguese tier system of planning also includes two types of strategic plans; the Regional Plans (PROT) and a national framework document of planning policies, the so-called National Programme of Spatial Planning Policies (PNPOT). The planning system is complemented by a number of sector or area specific plans, such as the Plans for the Coastline (POOC) or the Plans for Protected Natural Areas (PAT).

Two important features of the Portuguese planning system are the preservation and enhancement of the natural resources through the constitution of two national reserves, the so-called National Ecological Reserve and the National Agricultural Reserve, the first designed to encompass and protect the most relevant biotic resources (it includes, for instance, the Natura 2000 network and all national nature protection areas) and the second designed to protect the best agricultural lands.

Recently, the need to contain the growth of all urban areas throughout the country was reinforced through national planning policy guidelines. Sustainable development policies across sectors and territories are clearly stated in the PNPOT (2007) in close articulation with the National Strategy for Sustainable Development, the ENDS (2007).

Urban case study: The Parque das Nações in Lisbon

The project

The Parque das Nações urban development project covers 340ha, along 5km of the Tagus riverside, and is located in the municipalities of Lisbon and Loures. The project was initially conceived to host the Expo 98 Universal Fair and soon became the most ambitious urban project ever developed in Portugal.

Before the intervention, the entire project site was occupied by numerous heavy and polluting industries, including an oil refinery and related storage facilities. It was, in fact, an industrial site seriously contaminated and left almost totally abandoned after the closing down of most of the existing chemical industries. These circumstances opened up the opportunity to transform a typical brownfield site not that far from the city centre of Lisbon, into a high quality urban area, presently called Parque das Nações.

The urban concept that led the strategy, since the very beginning, was the reinforcement of the relationship between the city and the river. Large public green spaces were created, a complete set of new public infrastructures and transport facilities introduced and residential quarters built with shopping and office areas in between. In the end, the Parque das Nações became a new and popular centrality in Lisbon.

Although this project attracted and is still attracting large private investments the initiative was clearly public. Under the support of the Portuguese government, in 1993, the Parque Expo Company was created. This organization was given the responsibility for the conception, construction and management of the fair, as well for the conduction, in a second phase, of the urban renewal process that should continue beyond the fair.

Parque Expo is a public company. It's expected that by 2010 all company's work, in this project, will be finished and that all the buildings developed by Parque Expo will be, at last, in the private sector's control. All the interventions were framed by an Urban devlopment Plan and a series of Detailed Plans. While the Parque Expo responsibilities were the design and construction of the public space and buildings, the Portuguese government was in charge of the development of heavy infrastructures, such as the Vasco da Gama bridge and the Oriente railway station.

Strategy and goals

The more sensitive and valuable natural areas were protected, the green spaces turned abundant and pleasant and the walking and public transport were promoted. In the energy and emissions' field the project aimed at reaching a level of energy savings never achieved before in Portugal. It was, in fact, from the early stages, a project designed as an energy efficient urban space.

Its innovative building design and construction solutions namely the networked infrastructures, including electricity, water, gas, heating and cooling, and waste collection, all converge into one aim, to save energy. The two great goals defined to this intervention were: reducing the primary energy consumption to 50% of the Lisbon's average and to promote a decrease of 40% on the CO_2 emissions.

Urban infrastructures

The urban planning project offered an experimental site to test different ways to save energy. Among them stands out both building design and the adoption of a central system of cooling and heating that serves the entire area, as well as a technical gallery where all underground infrastructures are located, except gas pipes for security reasons.

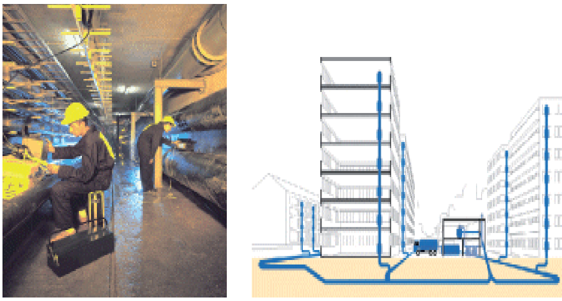

Figure XIV.v - Technical gallery and solid waste collection system

The technical gallery brings about a number of environmental benefits, namely the rationalization of the maintenance routines lowering air and noise pollution, the obstruction of public space and elimination of aesthetics impacts. Waste is pneumatically led to the central collection unit dismissing the use of waste trucks systems. It was also adopted a gas-based solution, encircling Parque das Nações, that produces electricity, hot and cold water by a co-generation process.

Site-specific Terms of Reference for Building and Indoor Climate Control Systems were proposed. The document enhances the role of clean energies for heating, cooling, ventilating and lightning, discouraging the use of commercial forms of energy. An explicit requirement of this document concerns building's overall energy performance. It limits energy consumption to 50% of the values imposed by Portuguese Regulations for passive systems. In addition, installed power standards are also reduced to 60%.

This document favours economic passive solar means as direct gain (45º rule), thermal storage in walls and floors, passive cooling through external shading, etc, followed by more sophisticated active solar means and, at the very last, by commercial energy-based systems. In parallel with the application of the Terms of Reference, some buildings were submitted to an evaluation, at design stage, concerning visual and thermal comfort, indoor air quality, environmental impact of construction materials and life-cycle analysis.

The quality of open air spaces was also considered since the early design stages, as well as the means of manipulating its climatic comfort levels considering the built environment potential contribution. This was possible due to the use of computer simulation programmes aimed at climatic control, using thermal, radiation and wind data. A guide was prepared to estimate environmental and energy costs, along the lines and procedures of the BREEAM´s methodology (U.K.).

Evaluation

There has been continuous measuring and studying of, in particular, the three following indicators:

- CO2 emissions within the boundaries of Parque das Nações;
- Energy needs of individual buildings throughout the year (for heating and cooling);
- Overall consumption of renewable and non-renewable resources for energy production to satisfy all sorts of needs generated in the Parque das Nações (including transports, infrastructures, street lighting, etc).

The evaluation is still going on thanks to an Observatory Centre for energy management. The Centre collects all data related to measurable energy parameters which are used for demand-side management studies.

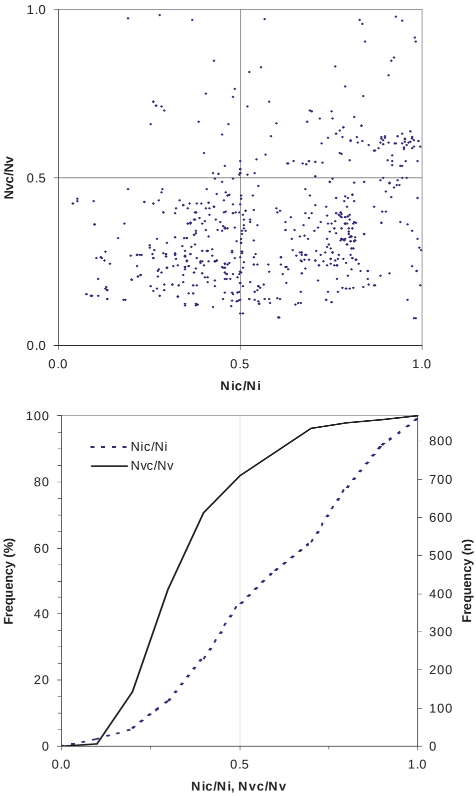

Figure XIV.vi - Taking the Portuguese Regulation values equal to 100%, the graphs show energy needs of buildings, during heating and cooling seasons, reduced by 50% and 20%, respectively (source: Oliveira Fernandes, 2006)

So far, the most important results are a significant reduction of CO_2 emissions due to the use of renewable energies, around 70%, the accurate definition of the energy needs of buildings trough rational consumption units (graphic 2 and 3), and the reduction of the installed electricity peak power. Although the final results have not reached entirely the benchmark figures set up initially, they have to be considered highly positive.

Conclusions

The EXPO'98/Parque das Nações project presented a unique opportunity to join a wide rage of experts to develop a project out of a brownfield that would become a model from an energy/environment point of view.

The outputs are of a different nature and level of impact, but are all relevant for the energy/environment debate in today's cities and represent a promising evidence for the future. The positive results of the evaluation are due to the application of simple rules to building design that take into account local conditions, such as radiation, thermal and wind figures, enhancing the contribution of buildings to create a comfortable and energy efficient internal and external environment. Buildings are number one energy consumers in OCDE countries. The EXPO'98 experience proved it is possible a significant reduction of energy consumption levels in inner city spaces.

City case study: Oporto Metropolitan Area

The metropolitan area of Oporto is the second largest in Portugal with over 1.2 million inhabitants. From a spatial structure point of view it is a polycentric urban system gravitating around the municipality of Oporto. The system comprises another eight municipalities, five of which in close vicinity to the core city of Oporto, constituting the so-called Greater Oporto. The maps below represent the AMP, the Metropolitan Area of Oporto with 9 municipalities.

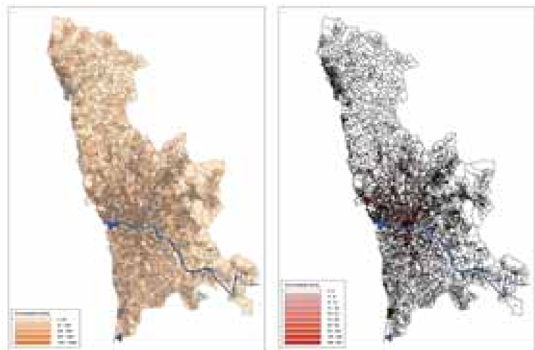

Figure XIV.vii - The population density map on the left contrasts with the employment density map on the right. The spatial pattern of employment distribution still is far more concentrated than the population pattern, making evident an uncontrolled sprawl phenomenon (source Planning Laboratory – CITTA)

From the 1950s onwards, the shape, functions and land use patterns evolved from a typical star with urban corridors towards the satellite cities, to a more complex shape, more difficult to characterise, due to intensive sprawl and the disruptive effect of the superimposition of a trunk road network made of new radials and circulars.

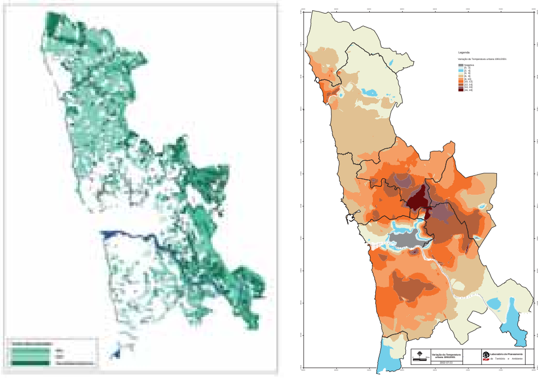

Figure XIV.viii - The green-blue structure of the metropolitan area on the right and the changing demographics dynamics expressed in urban temperatures for the interval 1991-2001, on the right. The 'donut' effect is quite evident (source Planning Laboratory – CITTA)

In this geographical context the private car has steadily gained importance and is already responsible for the majority of trips within the metropolitan area.

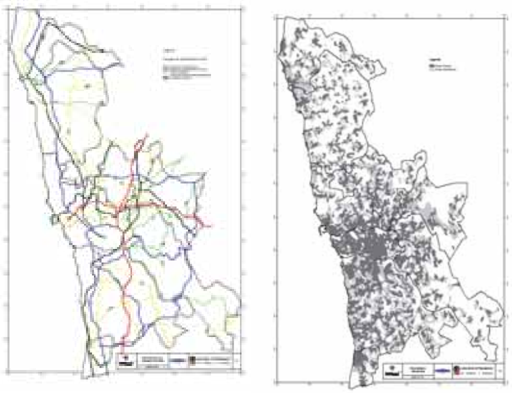

Figure XIV.ix - The map on the left represents the trunk road system and the main railway system, whereas the map on the right shows the urban areas, in darker grey and the expanding areas in lighter grey. It is obvious that planning policies are failing to address sprawl (source Planning Laboratory – CITTA)

Indeed, from 1990 to 2000 there was a rapid decline of the share of public transport. This downward trend was sustained and reversed with the recent introduction of a new light rail system that has been a success story despite the local controversy about the design of some lines of the network (already with 60km long) and the plans for future expansion.

Spatial planning is carried out by the different local planning departments of the nine municipalities with a difficult overall coordination from the Metropolitan Junta (Junta Metropolitana do Porto - JMP) and the Regional Development Commission (Comissão de Coordenação e Desenvolvimento Regional do Norte-CCDRN) because effective powers and policy instruments are clearly lacking.

The Northern Regional Plan which entirely includes the Oporto Metropolitan Area is close to being finally approved but some doubts exist as to the capacity of this strategic planning document provide the necessary and clear cut guidance to future development initiatives with an impact on this metropolitan area.

GENERAL DATA	
Resident Population	1260680 inhabitants
Employment	614800 workplaces
Metropolitan surface	814.7km2
Urban areas[1]	474.5km2
Green-blue structures	356km2
Gross population density	1550hab/km²
GDP per capita	12640€
BUILDING STOCK	
Dwellings per 1000 inhabitants	541
Average age of the total stock	37 years
New construction (yearly output)	1.2 m²/inhab x year
Rehabilitation (annual	0.02 m²/inhab x year
Average building high	2 floors
LAND USE AND URBAN FORM	
Employment in the centre	21%
Residential concentration index[2]	1.33
Public green areas	6 km²
Street density in the urban area	12km/km²
TRANSPORT SYSTEMS	
Cars per 1000 inhabitants	355
Trunk road length per capita	0.15 m/hab
Street network length per capita	5.22 m/hab
Modal split (% of daily trips)	52 Car; 20 PT; 19 Walking ;1 Others
RESOURCE CONSUMPTION	
Urban area per capita	384.2 m²/hab
Residential floor space per capita	27.9 m²/hab
Energy use in buildings per capita	4215 Kwh/hab x year

Energy use in transports per capita	9740 Kwh/hab x year
PERFORMANCE INDICATORS	
CO_2 emissions per capita[3]	4ton/inhab x year
CO_2 per residential floor space	143 kg/m²

[1] - Urban areas include all areas within city boundaries with gross population densities above 250 hab/km²

[2] - This index is defined as the residents' average distance to the urban centre divided by the average distance they would have had if they were evenly distributed all over the urban area (Naess et al, 1996)

[3] - Monteiro, A.; Borrego, C.; Tchepel, O.; Santos, P. e Miranda, A. (2001). Inventário de emissões atmosféricas - base de dados Polar2. In actas da 7ª Conferência Nacional sobre a Qualidade do Ambiente, 18-20 Abril, Aveiro, Portugal, pp. 954-958

Table XIV.ii - Performance indicators for the Metropolitan Area of Oporto

There is an obvious lack of a metropolitan authority able to coordinate spatial planning policies and transport policies. This is a problem also felt in Lisbon and is partially associated with the centralised nature of decision making and the public administration system in Portugal.

Nonetheless, some aggregate indicators (see table XIV.ii) are lower than one would expect for a metropolitan area of this kind and importance, pointing out to a relatively efficient use of resources and energy.

National conclusions

Broadly speaking, Portugal provides a somehow mixed picture as far as the country's carbon performance is concerned. It is true that the country is already struggling to meet Kyoto's targets but, back in the 1990s, they were fixed at unrealistic low levels (1/3 lower than UK's and Germany's equivalent targets).

The country's economy changed dramatically in the last two decades, as well as the physical fabric of our cities and regions. There was an unprecedented growth and investment in the property market and a boom in consumption and in car ownership. National policies to decarbonise the economy have to be considered rather ambitious and there are clear signs that, at local level, changes are occurring towards a low carbon built environment. Decentralised technologies for energy production, based on the wind, the water or the sun, area rapidly spreading countrywide.

Spatial planning and transports are still lagging behind. Suburban sprawl and inner city decline, the other side of the coin, have to be tackled with more effective planning policies and economic and fiscal measures to internalise environmental externalities.

The same applies to the transport sector where the private car is becoming the dominant mode of transport in our cities and rural areas. Mobility policies based on the *predict and provide* paradigm have to be replaced by accessibility policies based on the *predict and prevent* paradigm. Recent commitments, at national level, to (re)invest in the railway system and on high speed trains and, at local level, to invest in the introduction or expansion of metro and light rail systems maybe a good sign of change in the right direction, i.e. towards a low carbon society.

Acknowledgements

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Parque das Nações case study – Parque Expo SA and Eduardo Oliveira Fernandes.

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XV Serbia

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National context

Serbia is located in South-eastern Europe in the heart of the Balkan Peninsula. It is bounded by seven countries. Serbian territory covers 88,361km^2. Within this territory there are 4706 (data for Kosovo and Metohia are missing) human settlements (Statistical Office of Serbia, 2000). Areas of Vojvodina and large river basins (the Sava, Danube and Velika Morava) are exposed to the heaviest urbanization pressures. The main rivers of Serbia include the Danube, Sava, Drina, Morava and Tisa. Forests and woodland cover 27% of Serbia, 40% is arable land and 21% of land is used as permanent pastures. It is a parliamentary republic. Serbia is divided into 24 districts plus the City of Belgrade. The districts and the City of Belgrade are further divided into municipalities.

The new legal framework for environmental protection was introduced in 2004 in the Republic of Serbia by the Law on Environment Protection, Law on Strategic Environmental Assessment, Law on Environmental Impact Assessment and Law on Integrated Prevention and Pollution Control. The new laws are harmonized with the EU Directives on Environmental Impact Assessment (85/337/EEC), Strategic Impact Assessment (2001/43/EC), IPPC (96/61/EC) and public participation (2003/35/EC). The Environmental Protection Agency (EPA) was established in 2004 as an institution within the Ministry of Science and Environment.

Climate

Climate of Serbia can be described as moderate-continental with more or less pronounced local characteristics. Spatial distribution of climate parameters are caused by geographic location, relief and local influence as a result of combination of relief, distribution of air pressure of major scale, terrain exposition, presence of river systems, vegetation, urbanization. The Republic of Serbia has two climatic zones with respect to construction requirements.

According to the Report prepared by Republic Hydrometeorological service of Serbia, the average annual air temperature during the last 50 years for the area with the altitude of up to 300m amounts to 10.9°C. The areas with the altitudes of 300 to 500m have average annual temperature of around 10°C, and over 1000m of altitude around 6.0°C. The lowest temperature in the period 1961-1990 was registered in January and ranged in the interval from –35.6% (Sjenica/mountain area) to –21.0°C (Belgrade). Absolute temperature maximum in observed period was measured in July and ranged in the interval from 37.1 to 42.3°C. Figure XV.i shows mean annual temperature for GMS Belgrade, through its deviation from the normal. The black line is the 5-year sliding mean, and blue pillars are the deviation from the normal, for each year.

The number of degree days (average DD), decisive for the heat demand, is between 2400DD and 3400DD for main part of the Serbian cities. Belgrade has an average value of 2450. The maximum value is about 5400DD for Kopaonik Mountain. There is a large potential for energy saving and a wide scope of viable energy efficiency measures in the building stock.

Major part of Serbia has continental precipitation regime with higher quantities in warmer part of the year. Majority of rains fall in June and May. February and October have the least precipitation. Due to the relief, slopes of high mountainous ranges and the influence of Mediterranean climate, the area of south western Serbia has the Mediterranean precipitation regime with the maximum in November, December and January, and the minimum in August.

The occurrence of snow cover is characteristic for the period from November to March, and sometimes even in April and October, while on mountains over 1000m it can also occur in other months. The majority of days with snow cover are in January when in average 30 to 40% of total annual number of days with snow cover occur.

Surface air circulation is to a great extent caused by topography. In winter part of the year winds from northwest and west prevail. During colder part of the year east and southeast wind, Koshava, dominates. Winds from southeast direction prevail in mountainous part of south-western Serbia.

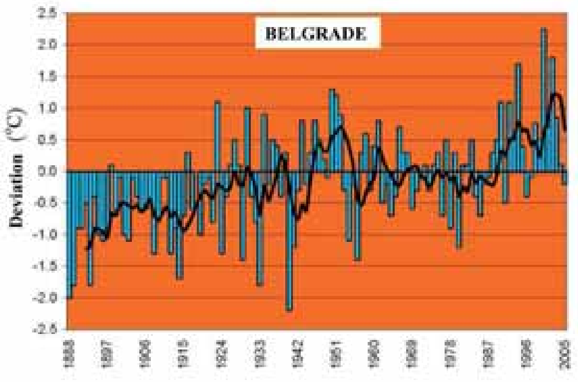

Figure XV.i - Deviation of main annual temperature in the period 1888-2005 in Belgrade from normal Reference period 1961-1990 (source: Republic Hydrometeorological service of Serbia)

Demographics

The population in Serbia is 7.5 million according to the 2002 census (Statistical Office of the Republic of Serbia). In 2000, 52% of population lived in urban areas. The main cities are Belgrade, the capital of Serbia (pop. 1,576,124), Novi Sad (243,151), Nis (177,823), and Kragujevac (145,890).

Carbon dioxide emissions

The total CO_2 emissions for 2004 for Serbia is 56.7 millions of tonnes, which is equivalent to 5.39 millions of tonnes per resident. According data for 2000, CO_2 emissions was divided into Solid fuels 29.15 millions of tonnes, Liquid fuels 7.9 millions of tonnes and Cement manufacturing 1 million of tonnes. Residential CO_2 emissions per capita is 242.5 kg CO_2 per person. Comparing the data for total CO_2 emissions per capita, for the period from 2000 to 2004, the increase of CO_2 emissions of 1.41 millions is noticed. (International Energy Agency (IEA) Statistics Division. 2006; WRI 2005, available at http://cait.wri.org)

A preliminary analysis estimates that the carbon abatement potential in Serbia is in the range of 20 Mt CO2eq to 25 Mt CO2eq per year.3 The resulting potential investment to mitigate greenhouse gas (GHG) emissions can be expected to range between 120 M EUR and 225 M EUR per year with valuated market prices ranging between 6 and 9 EUR/t of CO2eq (CDM Portfolio, Italian Ministry for the Environment, Land and sea, 2007).

Energy in Serbia

Serbia is not rich in energy resources. With the current level of production, which provides only 25% of the country's needs, Serbia (excluding Kosovo) is expected to exhaust its coal supplies within the next 55 years, and oil and gas supplies within 20 years (Environment in Serbia: an indicator-based review, EPA, Belgrade, 2007). Hydroelectric power capacity has been estimated at 14,200GWh per year. The potentials of other, renewable energy sources, including biomass, small hydroelectric power plants, geothermal, wind and solar energy, are very significant and exceed 3.8Mtoe. Some 63% (2.4Mtoe) of the potential renewable energy resources described lie in the utilization of biomass (wooden and agricultural biomass). Energy potential of the existing geothermal springs in Serbia is nearly 0.2Mtoe, and that of small hydroelectric power plants 0.4Mtoe. Figure XV.ii shows primary energy demands by fuels. There are 50 city heating plants in Serbia with total heat energy capacity of 6,597MW.

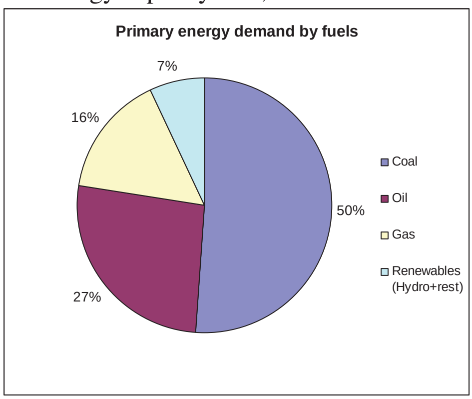

Figure XV.ii - Primary energy demand by fuel type

Serbia imports about half of its annual energy needs. This percentage has grown substantially over the past several years, mainly due to a rise in the consumption of oil derivates and gas, which are mainly imported (domestic sources cover one-fifth of crude oil consumption and one-tenth of gas consumption). Final energy consumption rose by some 18% in the period 2004-2006. The highest growth has been recorded in the industry sector (nearly 40%). When fuel sources are considered, it can be seen that solid fuel (coal and wood) consumption has risen by nearly 80% from 2004 to 2006. Gas consumption is also on the increase (with 15% rise over the same period). Liquid fuels and electricity still command the greatest share in Serbia's final energy consumption. Electricity consumption has been growing over the past years, mainly due to consumption by business; electricity consumption by households has also grown, especially in 2005, 2006 in relation to 2004.

Building regulations

The Serbian building regulations that might be considered as relevant to the implementation of EPBD (Energy Performances Building Design), include regulations that treat humidity prevention, thermal, air, acoustical and light comfort, standards and technical regulations relating to district (central) heating and hot water, ventilating and air conditioning systems. Serbian standards are based on DIN and ISO standards and have to be updated and brought in line with new DIN and ISO standards.

The Building Regulations are the responsibility of the Serbian Institute for Standardization. Development of building regulations is influenced by Ministry of Capital Investments and Ministry of Science, Agency for Energy Efficiency, Agency for Environmental Protection. The Serbian Institute for Standardisation is involved in regulations development. Regulations are by Ministry of Capital Investments, Ministry of Science and Serbian Chamber of engineers, put into effect. They finance and provide representatives for development of building regulations. Agency for Energy Efficiency and Agency for Environmental Protection are engaged in research and development of building regulations.

EPBD implementation

Until now EPBD (Energy Performances Building Design) legislation is not in use in Serbia.

Energy performance certificates

Energy performance certificates do not exist.

Other initiatives

Following measures with an aim to reduce energy and fuel consumption and CO_2 emissions are carried out:

- A special tax for different levels of electricity consumption.
- Tax payable for consumption of fuel.
- Different taxes presented for automobile registration according to the type of fuel.
- Sustainable transportation with railway electrification.
- Introduction of gas-lines.

Case study 1: Amadeo, energy efficient house in Belgrade

Context

In the Southeast part of Belgrade, in Zvezdara municipality, precisely in the part of Veliki Mokri Lug, the energy-efficient apartment house Amadeo is located. The location is in the larger-city area, close to the highway, on the northeast, and to the housing settlement Medakovic III, on the northwest (Figure XV.iii).

Figure XV.iii - Location of apartment house Amadeo on the map of central and south-east area of Belgrade

The location is characterised by low residential density. It is detached house with no shading obstructions in the surroundings, giving favourable conditions for solar systems integration. Belgrade has a moderate continental climate, with four seasons which influenced building construction design. The characteristic of Belgrade climate is also Košava - the southeast-east wind, with an average speed of 25-43km/h, but certain strokes can reach up to 130 km/h. Košava is the largest air cleaner of Belgrade.

Apartment house Amadeo is energy efficient building designed and constructed by Kuce Beodom, contractor that is committed to build apartments spending less than 90kWhpe⁄m²⁄year (kilowatt hour of primary energy for square meter and per year for heating, cooling, sanitary hot water, ventilation and light). Regarding the threshold of primary energy consumption apartments are rated as class B according to the France norm Effinergie (www.beodom.com). Low-energy consumption is obtained by energy efficient building construction and using renewable energy to replace the energy derived from fossil fuels (Figure XV.iv).

Figure XV.iv - South facade of Apartment house Amadeo (photo Kuće Beodom, www.beodom.com)

Apartment house Amadeo has 11 apartments, from 44 to 85m^2, on 3 levels (Figure XV.v). Usable floor area is 607m^2, but including balconies about 650 m^2.

Figure XV.v - Apartment house Amadeo-layouts of the first (left) and the second floor (right) www.beodom.com

The Building

Energy efficiency comes with excellent thermal insulation and smart choice of building materials and usage of renewable energy sources.

Building Structure

Structure of apartment house Amadeo is built with clay blocks, with thermal bridges break, and windows with low-e glazing filled with argon are applied.

Walls made of POROTHERM 38 clay blocks with thermal mortar (Figure XV.vi), have a thermal transmittance U=0.35W/m^2K, i.e. total thermal resistance R=2.86m^2K/W (www.beodom.com). The wall system fulfils both static and thermal insulation function, provides healthy indoor climate and very good thermal inertia needed for comfort in summer.

Figure XV.vi - Placing horizontal and vertical cerclage elements with thermal insulation on Apartment house Amadeo (photo Kuće Beodom, www.beodom.com)

The thickness of clay blocks allows thermal bridges to be broken on the floor slabs by placing a cerclage element with thermal insulation all around the concrete floor. For vertical reinforcements typical corner elements are used. They are specially designed to fit in a POROTHERM 38 wall together with 5cm of thermal insulation and a POROTHERM 8 brick. For the part of the ceiling that is directly under the roof, the insulating material is applied directly under the roof (20cm thick layer, or two 10cm thick layers of the same material). That gives a thermal transmittance around 0.18 W/m^2K.

Windows are a key component of a low-energy construction. Ideally, they should have a U-factor as close as possible to the one of the walls. Windows made of Alphacan 5-chambers PVC profiles, with low-e double-glazing and argon fill, having U-value around 1.2 W/m^2K, are selected. Rolling shutters with thermal insulation are integrated in the wall on top of the frame.

Usage of Renewable Energy

Because the construction of apartment house Amadeo is energy efficient, the demand on heating and cooling is greatly reduced. To further save energy, renewable energy is used to provide heating and cooling.

Figure XV.vii - Passage of the geothermal probes into Amadeo building (photo Kuće Beodom)

Geothermal energy is used for the low-temperature floor heating system in apartments in Amadeo house as well as to provide hot sanitary water. Ground source heat pumps offer excellent energy savings as up to 75% energy for heating can be extracted from the ground (www.beodom.com). Heat pump is connected to several vertical probes going 100m below ground. The closed loop of pipe is installed in the ground and filled with glycol anti-freeze mixture (Figure XV.vii). The fluid is warmed by the latent heat in the ground to about 10-12°C. It is pumped to the heat pump where the heat is transferred to the closed pressurized compressor circuit in the heat pump. The heat pump then provides warm water for the heating system. Electricity is used to run the compressor and circulate the fluids to exchange heat. Geothermal energy works best when used together with under floor heating, which requires low water temperature to heat the home. Additionally, each apartment is equipped with a Schiedel chimney allowing a complementary heating system such as wood or coal burning stove or a cooker to be connected, 75% of the energy used by the system comes from the ground for free.

One of the big advantages of the heat pump, besides cost saving on heating, is the possibility to reverse it in summer to provide cooling. The same under floor pipes used for heating can also be used in summer for cooling. Floor cooling is carefully controlled to prevent condensation. It works best on tiles and is not compatible with wood or laminate flooring. Additionally to floor cooling, ducted fan coil cooling is provided. The cold water coming from the heat pump is circulated in a fan coil which injects cool air in the room. Cooling with ducted fan coils can be used as an exclusive solution (instead of floor cooling) or as a complementary solution to the floor cooling.

Figure XV.viii - Solar thermal panels on the roof of Amadeo building (photo Kuće Beodom)

Solar thermal panels are the perfect solution to provide sanitary hot water, Solar energy in Belgrade can cover up to 85% of the annual need of hot water. That much is saving in electricity. 2 water cylinders of 500 litres each and 12 solar thermal panels for a total surface on the roof of 25.7m² are created (www.beodom.com). Solar thermal panels are installed on the south part of the roof (Figure XV.viii, XV.iv). In order to resist to strong gust of wind Kosava they are tilted with 30°, the same as roof surfaces. Solar thermal panels are connected to central water cylinders that provide hot water for all apartments in one building. Additionally, the same water cylinders are connected to the geothermal heat pump that can complement solar energy in the cold season. Solar energy combined with geothermal energy can provide close to 100% of sanitary hot water needed all year round. It is a combination that saves electrical energy traditionally used to provide hot water.

Ventilation in Amadeo apartments is implemented using a passive stack ventilation system (Figure XV.ix). Fresh air enters from Duco inlet vents located on the windows of the living space (living room and bedrooms) while stale air is drawn up Schiedel ventilation channels located in the bathroom and in the kitchen. They stack up together to create several channels going up to the roof. Each channel is reserved for the air extraction of one room in one apartment. This is the optimum solution where there is no chance to mix the air from different rooms or from different apartments. This ventilation system is based on the natural air movement through the dwelling as a result of internal and external temperature differences and wind induced pressure differences.

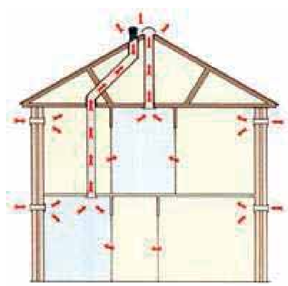

Figure XV.ix - Conception of natural ventilation in Amadeo building (source: www.ubbink.co.uk)

Cost analysis

The cost of flats in Amadeo house depends on the floor level and varies from €1350 to 1400 per m^2 (www.beodom.com). The price is relatively low for houses of this type and is aresult of the location that is in the larger-city area.

Carbon analysis

The high level of savings in terms of energy has been made by following design characteristics:

- Correct orientation and a compact building plan.
- Building construction of high levels of thermal insulation performances.
- The use of geothermal energy for space heating and cooling.
- The use of solar thermal collectors providing sanitary hot water; the use of the geothermal heat pump that can complement solar energy in the cold season.
- Natural and passive ventilation.

The renewable energy features reduce demand for fossil-fuels for heating and hot water provision. The remaining energy requirement is electricity for lighting, cooking and appliances.

The predicted energy collected by the solar thermal panels was estimated to be 21,450 KWh per year which could be described as "free" energy (www.beodom.com). Electricity costs are individually measured for each flat.

Key points

The beginning of 2009 is the deadline for completing the construction of the apartment house Amadeo. Monitoring data and evaluation of energy consumption are not still available. Some lessons learned include:

- Monitoring and evaluation of energy costs by comparisons of utility bills will be required in the future. At the moment, the figures are not readily available.
- Keeping checks on system performance is going to be an increasingly valuable investment in the low and zero carbon economy.

Case study 2: Improvement of housing settlement Konjarnik, Belgrade

Context

Until the seventies, in Belgrade, buildings were designed without consideration to energy demands and consumption. According to the data collected by Serbia Statistical Office, about 55% of the total of 583,908 existing housing units in Belgrade was built in this period (Krstić-Furundzic, Bogdanov, 2003). Rules of orientation of houses and flats were not observed and lot of flats with one-sided orientation, north or south, and too large windows were created. Insufficiency or absence of thermal insulation and improper construction details in terms of building physics are characteristics of mass post-war prefabricated apartment houses construction. Disregarding climatic conditions flat roofs were extensively used. They appeared functionally unsuitable, leaked, causing bad living conditions in flats underneath. Such buildings became "squanderers" of energy and poor ecology environments – "ill houses", badly influencing human health. Due to the great number of such houses, significant energy savings can be expected by refurbishment of inherited building stock in sense of improvement of energy performances.

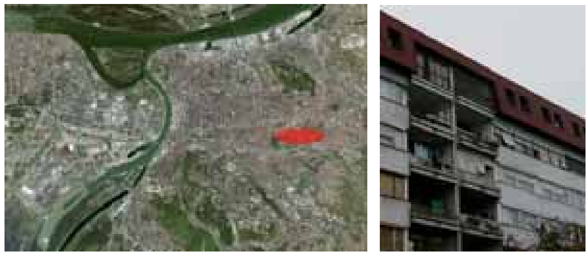

Figure XV.x - Location of Konjarnik on the Belgrade city map (left) and appearance of building (right)

Lots of housing settlements had been built in Belgrade after II World War. One of representatives of such architecture is housing settlement Konjarnik (Figure XV.x, left). Due to the city development, it is a part of the urban city zone about 4 km far from the city center nowadays. Konjarnik is selected as characteristic example of attic annex on the top of flat roofs, the action that is realized in significant number of housing settlements in Belgrade in the last twenty years.

So far, referential examples for improvement of energy performances of the existing building envelopes and usage of renewable energy can not be noticed in Belgrade. Because of that, hypothetical solutions for improvement of energy performances of the dwelling housing in Konjarnik and resulting environmental benefits are discussed. They represent results of the scientific research project "Development and demonstration of hybrid passive and active system of solar energy usage for heating, natural ventilation, cooling, daylighting and other needs for electrical power", financed by Ministry of Science and

Environmental protection of the Republic of Serbia (head of project Prof. Dr. Aleksandra Krstic-Furundzic). As the numerous housing settlements are characterized by similar building layouts and appearance, discussed solutions might be applicable for refurbishment of large number of buildings, indicating that energy savings and reduction of CO_2 emissions can be valuable.

The Existing Building

The settlement is characterized by large rectangular shaped residential buildings with typical south-north orientation; more exactly deviation of 10˚ to southwest is present. Numerous buildings with the same or similar layouts are present.

Existing Building Structure
The existing building was built in the late sixties of the 20th century as reinforced concrete prefabricated structure, with poor energy characteristics. Facades oriented south and north consist rows of windows and parapets, which represent 70% and verticals of loggias, which represent 30% of facade surfaces (Figure XV.x). Parapets are three-layer prefabricated panels consisting of internal concrete 10cm, thermal insulation 5cm and external concrete 5cm with finishing layer in ceramic tiles. The concrete frame is present along the edge of facade parapet panels resulting in the presence of thermal bridges. Thermal transmittance value of external wall is $U=1.034 W/m^2K$ (for Belgrade the limit value is $0.9 W/m^2K$), while for wooden box type windows $U>3.0 W/m^2K$ and the presence of the air infiltration is noticeable.

Attic Annex as the Refurbishment Measure

Existing refurbishment strategies applying on residential buildings in the settlement Konjarnik are transformations of flat roofs into slopping roofs by attic annex, which is municipality organized action and glazing of loggias, which is usually realized by tenants as illegal action.

For most cases, as well as for Konjarnik, situation before annex of attics was similar and can be described as follows (Krstic-Furundzic, 2007): :

- Mass postwar construction of housing structures with flat roofs.
- Suburban housing settlements looked monotonous and did not fit into the environment building spirit.
- The ratio of the number of inhabitants and free areas in the settlements allowed an increase in the housing stock.
- The flat roof proved to be functionally unsuitable in domestic climatic conditions.
- Inadequate technical solutions and building practice, as well as the poor quality of material, resulted in frequent leaking of the roofs, creating poor living conditions in flats underneath.
- Repair needs, as well as the insufficiency of housing space and high prices for newly constructed buildings, led to the phenomenon of mass building of attics on top of flat roofs, especially in suburban areas, as a kind of bioclimatic rehabilitation.

Decision making
During 90ties annex of attics was forced by township and government. Decision making about attics annex on flat roofs was managed in two directions: idea and benefits for the community (Krstic-Furundzic, 2007).

The idea was that by building attics on a top of flat roofs, it was possible to obtain:

- An increased number of housing units without increasing the number of buildings on the same site.
- The use of the existing infrastructure, thus reducing the costs per sq. m. built in the attic.
- A repair of flat roofs and improved living conditions on the original top floors, but improved technical conditions of the entire building.
- Better incorporation into the spirit of the environment and the existing structures.
- Visual identity of the existing buildings and suburban housing settlements from the Moderna period.

The most important benefits for the community, that gave support to annex of attics, were the following:

- Improvement of technical and living conditions in the whole building, especially on the original top floors.
- Efficient and cost-effective building of new dwellings, within the framework of the existing housing stock and infrastructure.
- Attainment of visual identity of buildings and settlements, with a positive effect upon the psycho-sociological condition of the users.

Construction principles
In general attic and existing standard floors construction can be in following relations (Krstic-Furundzic, 2007). (Figure XV.xi):

- Attic construction does not come from building system.
- Attic construction comes from building system.

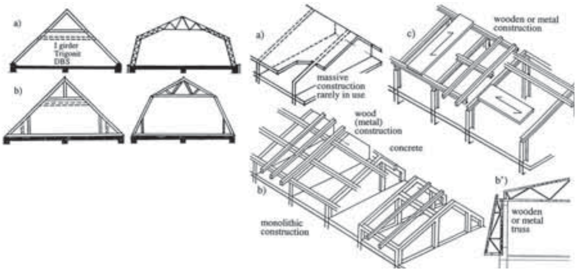

Figure XV.xi - Attic annex construction principles
Attic construction does not come from building system(left) and attic construction comes from building system (right) - a)the same material, b) mixed construction, c) construction continuity-different materials

In the case of attics annex at Konjarnik mixed construction with prefab wooden trusses is applied, as shown in Figures XV.xi-b' and XV.xii.

Figure XV.xii: Attic annex construction in Konjarnik

Cost analysis

Necessity for reconstruction of flat roofs and housing shortage, increased by great number of last civil war refugees from former Yugoslavia parts (about 300000 at Belgrade territory), and high prices for newly constructed buildings, caused massive annex of attics on top of flat roofs, built for the purpose of dwelling. Strategy is to increase the number of flats without increasing the number of buildings on the same site and to use the existing infrastructure, thus reducing the cost per sq. m. built in the attic that varies from €700 to 1200 per m^2, depending on location and structure type, while price of newly constructed flats ranges from €1200 to 2000/m^2 (luxury apartments are not taken into consideration).

Carbon analyses

Building of attics on a top of flat roofs improve technical and living conditions in the whole building, specially on the original top floors. It reduces energy consumption, but significant reduction of CO_2 emission can be obtained by improvement of thermal-insulation of existing external walls. Index of reduction of CO_2 emission will be the subject of next analyses.

Improvement of Energy Performances of Existing Building Envelope

Improvement of energy performances of the envelope of dwelling housing in Konjarnik includes following measures:

- Reduction of energy consumption for space heating by improvement of envelope structure.
- Reduction of energy consumption for water heating by application of solar thermal collectors.

Hypothetical models for improvement of building envelope are created and the annual energy savings for space and domestic water heating, as well as reductions of CO_2 emissions, according to the models are recognized. Yugoslav standards for Thermal Protection are in use for renovation of existing buildings.

As buildings in settlement Konjarnik consist of number of lamellas, the central lamella was the subject of consideration with effective heating surface of 1,250m^2.

Reduction of energy consumption for space heating by improvement of envelope structure

Decision making

Design for improvement of the envelope of the existing building is created according to Belgrade climatic conditions, building orientation and technical characteristics of the existing building structure. Two hypothetical models for improvement of building envelope are designed and for simulation of building energy performance 3D mathematical models are created (Kosić, Krstić-Furundžić, Rajčić, Maksimović, 2009).Measures for improvement of building envelope:

Model 1:

- Laying of 5cm of expanded polystyrene onto the facade parapet panels, resulting in total insulation thickness of 10cm and U=0.371W/m^2K.
- Replacement of existing windows with double glazed windows (4+12+4), made of five-chamber PVC profiles resulting in U=2.3W/m^2K. Predicted exchanges of the air flow for Model 1 is 2 - 3 exchanges per hour.

Model 2:

- Laying of 10cm of expanded polystyrene onto the facade parapet panels, resulting in total insulation thickness of 15cm and U=0.255W/m^2K.
- Replacement of existing windows with triple low-emission glazed windows with argon filler, made of five-chamber PVC profiles resulting in

U=0.255W/m^{2}K. Predicted exchanges of the air flow for Model 2 is 0.8 - 1 exchanges per hour.

Common measures for both models:

- Laying of 10cm of hard mineral wool onto the attic slab resulting in total insulation thickness of 22cm and U=0.171W/m^{2}K.
- Glazing of loggias with thermo insulating glass panels (4+12+4), laid in five-chamber PVC profiles (U=2.3W/m^{2}K).

Reduction of Energy Consumption for Space Heating

For existing building in Konjarnik, data of average annual energy consumption for space heating in the last two years (2006-2008, for the periods from 15th October to 15th April) are gathered from Belgrade Public Utility company for heat supply. According to these data estimation of annual energy consumption for heating of central lamella, as subject of observation, is realized. For simulation of building energy performance of improved models, 3D mathematical models are created.

Model of the building	Energy consumption (kWh)	Energy consumption (kWh/m^2)
Model of the existing building	353810.00	283,60
Model 1	37242.89	29.79
Model 2	18446.15	14.75

Table XV.i - Annual energy consumption for space heating according to the models

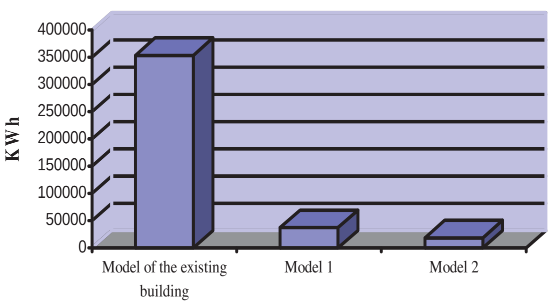

Figure XV.xiii - Annual energy consumption for space heating in existing building and improved models

Comparing to energy consumption for heating of existing building, the primary energy consumption for space heating is reduced by more then 66% in case of Model 1, while in case of Model 2 reduction amounts more than 83% (Figure XV.xiii and Table XV.i and XV.ii).

Model of the building	Yearly energy demand reduction. (kWh)	Yearly energy demand reduction (kWh/m^2)
Model 1	316568	254
Model 2	335364	269

Table XV.ii - Reduction of annual energy demands for space heating according to the models

Carbon analyses

District heating is available in housing settlement Konjarnik, and water heating is based on fuel oil. In Table XV.iii, values for yearly CO_2 emissions reduction by improvement of building envelope energy performances are presented for both models.

Model of the building	CO_2 reduction (kg/year)
Model 1	82307.45
Model 2	87194.61

Table XV.iii - CO2 reduction

According to presented results, significant reduction of CO_2 emissions can be achieved by improvement of building envelope.

Reduction of energy consumption for water heating by application of solar thermal collectors

Decision making

Hypothetical models for integration of solar thermal collectors are created with aim benefits of solar systems application on residential buildings in Belgrade climate conditions to be estimated. Four distinctive variants of positions for solar thermal panels integration on building facade were selected (Krstić-Furundžić, Kosorić, 2009):

- I Design Variant: roof 40°, area of 100 m^2 (Figure XV.xiv-a) - solar panels with slope of 40° applied on the roof.
- II Design Variant: parapet 90°, area of 90 m^2 (Figure XV.xiv-b) - vertical position of solar panels.

- III Design Variant: parapet 45˚, area of 120 m^2 (Figure XV.xiv-c) - solar panels with slope of 45 applied on parapets.
- IV Design Variant: sun shading 0˚, area of 55 m^2 (Figure XV.xiv-d) - horizontal position of solar panels.

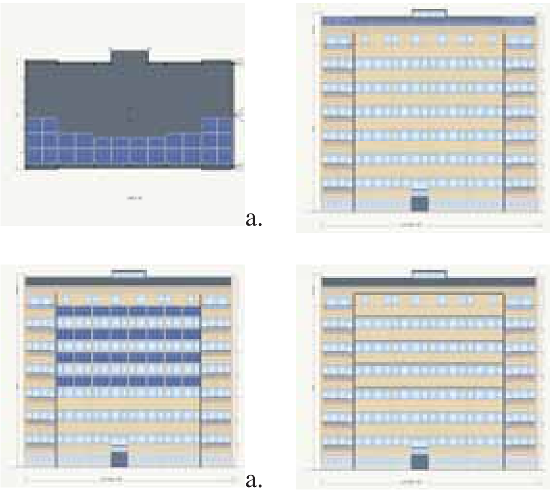

Figure XV.xiv - Design variants: a. I Design Variant: roof 40˚ (roof and facade layouts), b. II Design Variant: parapet 90˚, c. III Design Variant: para pet 45˚, d. IV Design Variant: sun shading 0˚

Consumer

There are 28 apartments in one lamella and 90 occupants inside them altogether. The initial idea was to explore potential and effects of solar thermal collectors to meet energy demands for hot water. In calculations, real thermal energy consumption was taken into consideration. Thermal energy for hot water: 80*l* of hot water per person per day, 80*l*x90=720*l* (20-50°C) per day for one lamella which presents 251kWh per day, i.e. 91618.3kWh per year for one lamella.

Solar Thermal System

Calculations and simulations of solar thermal systems for all design variants were done in Polysun 4 Version 4.3.0.1. In calculations, the existing water heating system fully based on electricity was substituted with the new system – solar thermal collectors (AKS Doma – manufacturer), with the auxiliary system powered by electricity.

Reduction of Energy Consumption for Water Heating

Energy performances for design variants of solar thermal collectors integrations in existing building envelope are presented in Figures XV.xv, XV.xvi, XV.xvii (Krstić-Furundžić, Kosorić, 2009). .

It can be noticed that in Belgrade climatic conditions, significant energy savings for water heating can be achieved by solar thermal collectors. Solar thermal panels with slope of 40° proved to be the best solution regarding heating energy demands satisfactions.

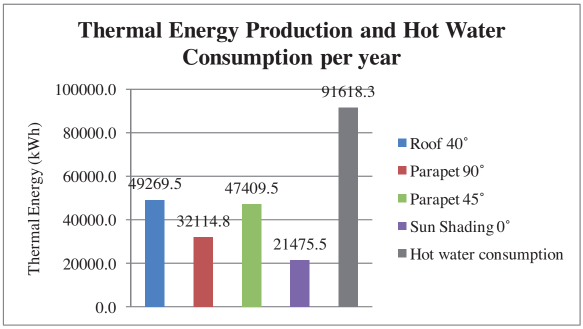

Figure XV.xv - Thermal Energy Production and Hot water Consumption per year

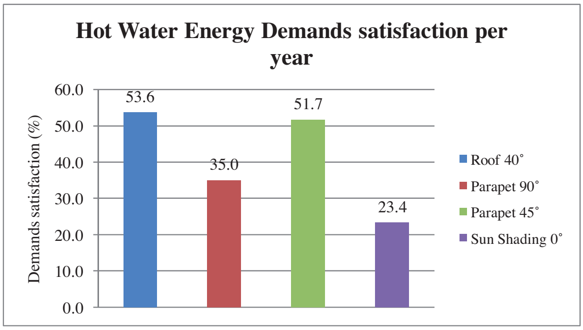

Figure XV.xvi - Hot Water Heating Energy Demands Satisfaction per year achieved by solar thermal collectors

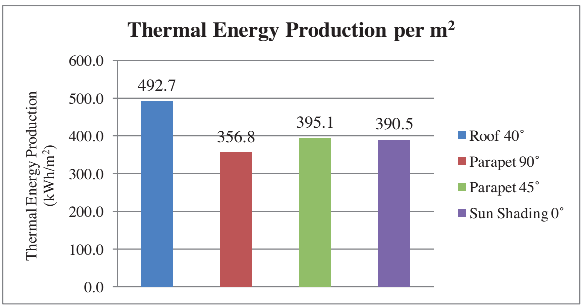

Figure XV.xvii - Hot Water Energy Production per m2 of Solar Thermal Collectors

Cost analysis

Simple payback periods for Design Variants 1, 2, 3 and 4 are sequent 7, 9, 8 and 8 years.

Carbon analyses

In Table XV.iv, values for CO_2 emissions reduction are presented for all proposed design variants.

Solar thermal collector position	CO_2 reduction kg/year
Roof 40°	39908
Parapet 90°	26013
Parapet 45°	38402
Sun Shading 0°	17395

Table XV.iv - CO_2 reduction achieved by solar thermal collectors

Lessons Learnt

In Belgrade, as well as in Serbia, there are a large number of housing settlements with the same or similar prefabricated buildings, as in case of settlement Konjarnik, indicating that significant energy savings and CO_2 emission reductions can be obtained.

Planning legislation

The new legal framework for planning and construction was introduced by the Law on Planning and Construction in the Republic of Serbia in 2003 (Published in the Official Herald of the Republic of Serbia no. 47/2003). Also, new Law on strategic environmental impact assessment was introduced in 2008.

City case study: Belgrade

Background

Belgrade is the capital and largest city of Serbia. The city lies on two international waterways, at the confluence of the Sava and Danube rivers. With a population of 1,630,000 (official estimate 2007), Belgrade is the largest city in the territory of the former Yugoslavia, second largest city on the Danube river and the fourth largest in Southeastern Europe, after Istanbul, Athens, and Bucharest. Belgrade has the status of a separate territorial unit in Serbia, with its own autonomous city government. Its territory is divided into 17 municipalities, each having its own local council. It covers 3.6% of the territory of Serbia, and 24% of the country's population lives in the city. Belgrade is the central economic hub of Serbia, and the capital of Serbian culture, education and science. The density of inhabitance is five times bigger from the average density in Serbia.

Context

The development of the Belgrade metropolitan region has mostly been a product of centralised power at the state level, but the noticeable imbalance has also been the result of uneven national development, as well as a consequence of wrong decisions and complex socio-economic conditions. For example, the majority of investments have been directed to Belgrade which has caused the stagnation of other Serbian cities and areas. The influx of people reached its peak between 1970s and 1990s when Belgrade gained approximately 15.000 inhabitants every year. Additionally, during the 1990s Belgrade also absorbed a considerable wave of immigrating population, including the war refugees from the former Yugoslav republics and internally displaced people from Kosovo and Metohija who looked for a new permanent residency. This situation has generated some serious problems for the increasing population triggering a spontaneous and uncontrolled development of city-edge settlements, usually without an adequate infrastructure. The traffic congestion with insufficient public transportation connections to the other parts of the city has become an unpleasant reality which, finally, caused higher costs of urbanisation.

Figure Xv.Xviii - Unplanned settlement in Kaludjerica (Belgrade)

The legacy of the 1990s and the current urban transformations both influence the level and the structure of CO2 emission. However, the available data could provide only a partial picture of existing problems, which are nowadays mostly caused by the scale and (dis)position of numerous unplanned settlements (Figure XV.Xviii) and traffic problems. For example, according to the data from 2000, about 30% of all CO2 emissions in Serbia were connected to the building stock. According to the researches from 1996, only 20% of the buildings in the peripheral areas of Belgrade were actually planned and/or regulated by some spatial plan, and only 35% of them had some kind of technical documentation Today, the estimations are that in ten Belgrade's municipalities there are over 200,000 illegally constructed objects. As a result, most of the settlements on the periphery do not have a basic infrastructure - around 90% of housing units (flats) have electricity, 65% are connected to the public water system, around 20% are connected to the sewage disposal system and only 5% have distant heating (Djukic, Stupar, 2009).

Objectives and solutions

The master plan of Belgrade 2021 underlines the problems of illegal construction, distribution of functions (Belgarde is monocentric city) and traffic, which cause a negative impact on living environment and - directly and indirectly - increase the level of CO2 emission. It includes several objectives and measures which should tackle this sensitive issues. Some of them are more general and they encourage efficient management and optimal usage of potentials of Belgrade for public benefits and coordinated general and individual interests. At the same time, the plan emphasizes the idea that the existing tissue should be completed with limited linear expansion, while the improvement of the existing networks, technical, communal and transportation systems represents a necessity for the future protection of environment, employment, education and public health. The city would transform from monocentric to multycentric (two more centres are planned – one in New Belgrade and another one next to Danube.

The set of objectives is also related to the economic, social and environmental improvement of poor and illegal settlements, their (re)arrangement and transformation - without compromising the public interest. According to the plan, these settlements should be urbanized, remediate, legalized and integrated into the city tissue, while an important role is given to various institutions - secretariats, the City Planning Agency and Agency for Urbanization that should prepare adequate procedures for quicker responses to investors' requests (Djukic, Stupar, 2009).

The importance of an efficient combination of market and planning measures and instruments is stressed instructing the new, socially acceptable city planning parameters and standards for market-oriented housing construction, socially financed dwellings and remediation of non-hygienic settlements.

However, we should be aware that even small, but well integrated interventions and initiatives could stimulate actions that gradually change the whole image of these neglected and chaotic urban areas. The first step should definitely be a renovation of existing buildings and improvement of their thermal isolation. Furthermore, the capacity of inadequate street networks should be adjusted to the current situation and new number of inhabitants which means that public transportation needs to be modernized and intensified. The next step could take these urban areas towards some new solutions - stimulating water and waste recycling, promoting alternative energy resources and supporting creative and 'clean' ideas which could prevent and/or decrease unnecessary emission of CO2.

Urban case study: Infrastructure case study – Light metro in Belgrade

Background

Belgrade is the capital and largest city of Serbia. The city lies on two international waterways, at the confluence of the Sava and Danube rivers. With a population of 1,630,000 (official estimate 2007), Belgrade is the largest city in the territory of the former Yugoslavia, second largest city on the Danube river and the fourth largest in Southeastern Europe, after Istanbul, Athens, and Bucharest. Belgrade has the status of a separate territorial unit in Serbia, with its own autonomous city government. Its territory is divided into 17 municipalities, each having its own local council. It covers 3.6% of the territory of Serbia, and 24% of the country's population lives in the city. Belgrade is the central economic hub of Serbia, and the capital of Serbian culture, education and science. The density of inhabitance is five times bigger from the average density in Serbia. The inflow of inhabitants to Belgrade was highest in the period from 1970 – 1990, when the annual growth was about 15,000 inhabitants. Simultaneously, during this period about 7000 apartments were built, mainly on the outskirts of the town, influencing the increment of the urban tissue area. Since Belgrade is mono-centrical town and the great majority of central functions is located in the historical town core, the increase of town territory caused numerous traffic problems. Capacities of the public transport did not adequately follow the increase in mobility of the inhabitants, the number of employees and school children (the number of tours was increased from 0.7 in 1975 to 1.5 in 2001, while the number of seats in busses for the same period was increased 50%; however in the period from 1990 -2000 was decreased for 30%).

Context

The idea to construct a metro-like system in Belgrade is a relatively old one, and originates from the 1950s when it was driven by Belgrade's blooming number of inhabitants and the lack of adequate transport infrastructure. In the first visionary plans in fifties, consideration about metro as the principal transport system in Belgrade started. Those were the first steps in metro project which were especially intensified after Master urban plan was completed in 1972. Despite the quality of the prepared studies and designs, various approaches of experts and politicians to the needs and possibilities of highly capacitated rail system in Belgrade were the reason that decision about construction has not been taken till now. However, the inability to decide between proposals to construct a modern tram system and a classic underground one meant that the project was to stay largely stagnating in years to come. The political turmoil of the 1990 and lack of potential funding extinguished further development of the idea. With the beginning of the 21st century, however, the idea came to life once again. BELAM, consequently, became an integral part of Belgrade's Master plan for the year 2021. The main criteria for choosing light rail over conventional metro was the comparatively low cost (Pre-feasibility study, Belgrade, 2004). .

Description of the case study

The relevant network of the public transport system in Belgrade comprises following systems: city railway system, bus system, tram system and trolleybus system. Following Belgrade's Master plan for the year 2021, light rail network was planed. It consists of three lines. The project was presented to the public on 3rd July 2004.Construction was planned for completion in 2012. Three lines operate within the system (Figure XV.xviii):

Line 1 - Centralia - will link Novi Beograd on the left bank of the Sava river to the city centre and the eastern suburbs. The line will run underground from Saborna crkva to Vukov spomenik, total length will be 12.5 km, from which about 4.6 km will be underground, with 20 stations. This line is to be constructed first. The pre-feasibility study has it denoted as "primary". There are approximately 270,000 inhabitants and 150,000 employees in the direct impact area of the corridor.

Line 2 - Vracarska - will only run on the left bank of the Sava river. All stations except Hipodrom-Topcider will be underground.

Figure XV.xviii - Central line of Belgrade Light Metro

Line 3 - Savska - will link the southern suburbs to Novi Beograd, running underground from Banovo Brdo to Pozeska Ulica. The new light rail system will complement the existing tram and Beovoz suburban rail network, which has two underground stations in the city centre, Vukov Spomenik and Karadjordjev park.

Aims

The objectives of BELAM project are:

- improved efficiency of public system;
- reduction of traffic congestions;
- improvement of environmental quality (restriction of atmosphere pollution);
- reduction of the consumption of conventional fuel;
- reduction of coasts incurred by accidents;
- giving back streets to people;
- humanization of inter-human relations.

Funding

The project of BELEM is to be executed in phases. The assumed investment dynamics for the first line is 6 years. Total investment for rolling stock, consisting of 46 vehicles, amounts to 126.500 EU, so together with the investment for infrastructure and equipment, the value of the investment is around 400 million EU. Pre-feasibility study has shown that internal rate of returns is 9% (Pre-feasibility study, Belgrade, 2004)..

Three alternatives of financing have been studied, and each alternative has its own management model:
Planned alternatives are:

- financing from public sources;
- public-private partnership;
- mixed system

Each of these modalities has been tested separately and on the basis of experience, advantages and disadvantages of each, modalities have been determined.

Overall assessment–from a low carbon perspective

Approximately 40 million passengers will use BELEM annually. The light metro will reduce the number of busses (on half) as shown in Table XV.v and cars and also the travelling time (23 million hours less on annual basis). That will cause the reduction of consumption of conventional fuel (1.500 l for busses in a pick hour, which is 4.5 million litres per year).

The light metro usage will cause less carbon emissions because of reduction of busses and reduction of use of the private cars (Pre-feasibility study, Belgrade, 2004).

	Variant network -"without investment"		Network with the first line of light metro - basic variant		Network with the first line of light metro – variant with the station Academy	
	2002	2021	2002	2021	2002	2021
Number of passengers in buses at system level in peak hour	79642	117786	77513	114440	77627	114618
Average capacity of an empty bus	129		129		129	
Number of passengers in single vehicle	90		90		90	
Required number of buses in peak hour (for occupancy of 70%)	882	1304	858	1267	860	1269

Table XV.v - Number of passengers and required number of buses in system according to variants and years (source: Pre-feasibility study, Belgrade, 2004)

Lessons learnt

After years of searching for the optimal solution for the problem of public transport, Belgrade has got the project for the first line of light metro. This will solve one of the biggest problems in the city / public transport and traffic congestions.The realization of project will cause reduction of carbon dioxide, air pollution and noise. The future development of the project (possibility for development of metro) will cause important future reductions.

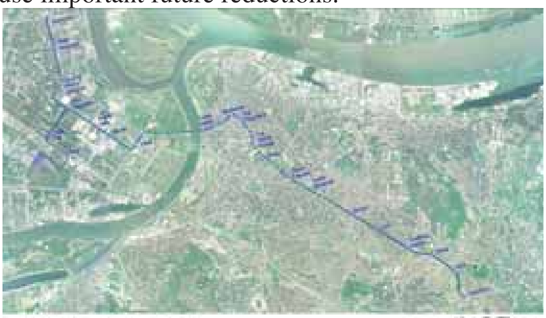

Figure XV.xix - Metro line

Conclusions

Serbia signed a few different agreements: UN Framework Convention on Climate Change – UNFCCC in 2001, Kyoto Protocol (Signed by Serbia and Montenegro in 1997, ratified by Serbia in 2007), Montreal Protocol (ratified by Serbia in 2004) and Vienna Convention in 1992.

Residential CO_2 emissions per capita is 242.5 kg CO_2 per person. Rapid decrease of CO_2 emissions during the last decade of 20^{th} century has followed decrease of GDP. Comparing the data for total CO_2 emissions per capita, for the period from 2000 to 2004, the increase of CO_2 emissions of 1.41 millions is noticed and it has been followed by increase of GDP and the growth in industrial output. Different government departments and agencies are involved in development of environmental protection strategy and consequently the reduction of CO_2 emissions.

In favor to avoid harmful environmental impact, energy policy in Serbia stresses the importance of the following incentives:

- Energy sources diversification – with particular point to renewable energy sources;
- Rational use of energy – consumption management and energy audits;
- Energy efficiency;
- In accordance with EU directives, EU strategic and regulatory documents, attaining Kyoto protocol goals, etc., Energy Development Strategy of the Republic of Serbia incorporates the incentive measures for investments into energy sector and as well as for subjects that use RES as energy source;
- Strategy sets up priorities for operating and development of energy sectors, stressing RES as well.

The Serbian building sector is slow to implement the most energy efficient building methods. The past development has been characterised by research projects and individual examples of eco-housing projects. The objectives in major spatial plans and general urban plans, which were adopted during the last two decades, are tightly connected to sustainable urban design principles regarding energy efficiency and ecology protection.

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XVI Slovenia

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National context

Slovenia is a democratic republic and social state governed by law. It became independent in 1991, after being one of the socialistic republics of former Yugoslavia since 1945. In 1st May 2004 Slovenia became a member of EU and member of NATO.

GDP in Slovenia (2008 estimate) is the second largest among new member states, i.e. $29,472 per capita or 90% of the EU average. Traditional regions of Slovenia are based on the former four Austrian-Hungarian empire crown lands (Carniola, Carinthia, Styria and the Littoral), and have recently been redefined according to EU rules into eight regions: Upper Carniola, Lower Styria, Prekmurje, Carinthia, Inner Carniola, lower Carniola, Goriska and Slovenian Istria; with growing responsibilities for developing regional and local environmental policies.

Climate

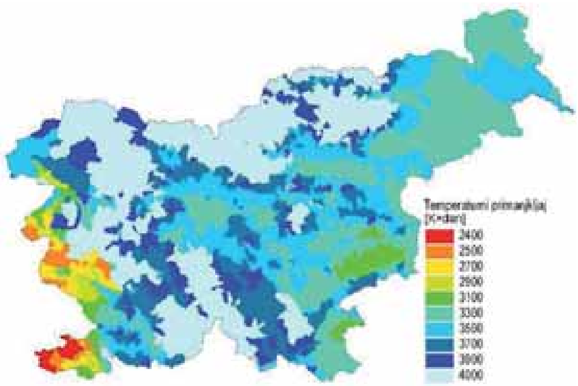


Figure XVI.i - Degree-days (20/12) for Slovenia, (Source: Regulation for thermal regulation and energy efficiency in building, 2002)

Slovenia covers 20,273 km^2 stretching between Alps, the Adriatic and the Panonian plain. In spite geographically small size, it links different landscapes: Alpine and Mediterranean, Panonian and Dinaric, each with its characteristics and unique features. Almost 56% of the country is covered by forest; 35% of area is part of NATURA 2000 areas. The climate is ccontinental with mild to hot summers and cold winters in central Slovenia and in plateaus and valleys to the east, Alpine in the north-west, sub-Mediterranean along the cost and its hinterland. Average temperatures in Slovenia are: January: -2^{o}C, July: +21^{o}C. The average rainfall is 1,000 mm at the coast to 3,500 mm for Alps and 1,400 mm for central Slovenia. Typical heating Degree-Days for central Slovenia are 3300-3700 DD, and 2400-2700 DD in coastal region. The most relevant season for energy calculation is winter, according to the table XVI.i.

	Heating season	**Cooling season**
Most relevant season	**Most relevant**	
Duration (months)	8	1 - 3
Air Temperatures (Max, Min, Mean)	-13, 3, 10	38, 10 , 19
Degree Days Refer base temp. heating and cooling - 20/12, 20/21	Central climate: 3300 Alpine Climate: 4700 Mediterranean: 2400	Central climate: 79 Alpine Climate: 2 Mediterranean: 144

Table XVI.i - Average heating and cooling season

Demographics

Slovenia has a population of 1,964 million inhabitants (census 2002) of which 83.1% are Slovenians. The official language is Slovenian, in nationality mixed areas also Italian and Hungarian (national minorities). The average density of population 99 inhabitants/km^2 is less than in the majority of other EU states. The people have mainly settled the river valleys and transport routes, where long ago Slovenian towns began to emerge, whilst the mountainous and forested areas remain unpopulated. Approximately 30% of population lives in town with more than 10,000 inhabitants, whilst the rest live in nearly six thousand smaller towns and villages. The largest part of Slovenia's territory is taken up by the Alps, where 47.3% of the population lives. On the southern and eastern margins of the Alps there are high plateaus, covered mainly with forests. The pre Alpine hills and valleys are also a part of Slovenian Alps. The largest among valleys are Ljubljana (930 km^2), 619 inhabitants/km^2 and Celje basins. The capital, Ljubljana, is the largest city as well as the political, administrative, economic, educational and cultural centre of Slovenia.

Carbon dioxide emissions

In 2004 the emissions of greenhouse gases were listed as 19,946 millions of tonnes of CO_2 equivalent or approx 10 tonnes of CO_2 eq. per capita. In this amount the emissions of CO_2 are prevailing, as they represent 81% of all above registered emissions.

The Slovenian Operational Programme to Reduce Greenhouse Gas Emissions (OP RGGE) is based on the Kyoto commitments with the target to reach 8% reduction of CO_2 in the period 2008 – 2012 (i.e. 18.59 millions of tonnes of CO_2 eq.), referring to the base year 1986, when the green house gas emissions were 20.2 millions tonnes of CO_2 eq.

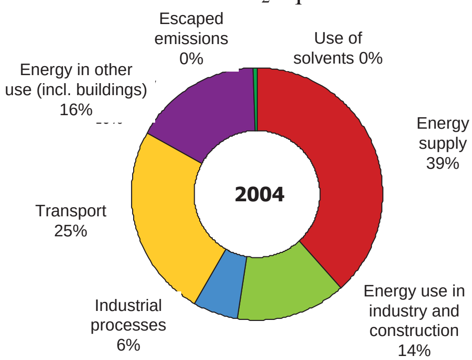


Figure XVI.ii - Share of CO_2 emissions in different subsectors for 2004 (Source: ARSO, GHG emissions evidence July 2006)

In 2004, CO_2 emissions due to energy use in other sector (incl. buildings) reached 2.828 kt CO_2 eq.. Between 2000-2004 the reduction of 7% (per base year 1986) was reached, while in 2004 an increase of 20% was detected. The Operational Programme to Reduce Greenhouse Gas Emissions (OP RGGE) planned the bellow measures in this field:

Improved energy characteristics of buildings and systems, increased use of renewables and switch to cleaner energy sources, green electricity production and better energy efficiency of appliances, lighting, AC.

In recent years, GHG emissions have been increasing markedly only in the transport sector; in the services sector, emissions have been falling. There was a rise in emissions in industry in 2004 and 2005 after several years in which levels remained more or less unchanged. In 2005 total greenhouse gas emissions were above the baseline year of 1986; this was due to the consumption of fuels for energy purposes. They rose considerably in comparison with 2004, which does not accord with the targets of the Kyoto Protocol and the Operational Programme to Reduce Greenhouse Gas Emissions (OP RGGE). In the 2000–2005 period, emissions rose by an annual average of 1.8%, mostly in the energy sector (2.9%), transport (3.7%) and industry (1.9%). In the services sector they fell by 3.2%.

Energy in Slovenia

Average energy end-use in the 2001–2005 period amounted to 55,356 GWh. Of this figure, 8,008 GWh is deducted because it was consumed by those entitled to be part of the CO_2 emission allowance trading system. All such persons operate within the manufacturing sector. Of the remaining use, the largest portion comes from transport, whose rapid growth makes it the most problematic energy end-use sector.

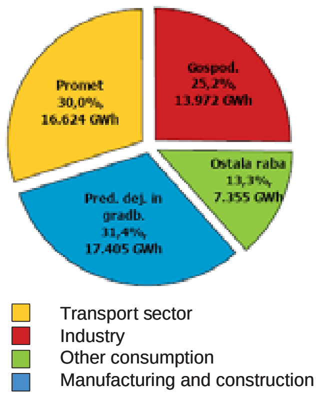


Figure XVI.iii: Structure of average final energy consumption 2001–2005 (including use by those entitled to trade CO_2 emission allowances). (Source: SORS and NEEAP)

Final energy consumption is rising constantly in Slovenia. Growth in final energy consumption in 2005 amounted to 1.7%, which is slightly less than the average annual growth rate recorded in the 2000–2005 period (2.1%). The increased consumption of liquid fuels (1.9% rise in 2005) and electricity (1.6% in 2005) contributed most to this growth. In 2005 the increased consumption of liquid fuels was higher than the growth recorded in the 2000–2005 period, while the rise in electricity consumption was lower (3.9%).

Liquid fuels accounted for almost half of final energy consumption in 2005 (48% of total final energy), followed by electricity (22%), natural gas (15%), renewable sources (9%) and district heating (4%). Coal accounted for only 1.6% of final energy consumption.

In final energy consumption in 2005, manufacturing and construction accounted for 35%, transport for 31%, and other sectors, together with the residential sector, for 34%. The share taken by industry and transport is rising at the expense of other sectors.

On the basis of the National energy efficiency action plan (NEEAP), Slovenia is to achieve cumulative savings of at least 9% in relation to the starting point for final energy consumption in the 2008–2016 period, or at least 4,261 GWh. The NEEAP rests on the implementation of 29 sectoral, multi-sectoral and horizontal instruments. The package of financial incentives for residential sector covers four programmes: energy-efficient renovation of buildings and sustainable building construction, energy-efficient heating systems, efficient electricity use, and the efficient energy use for low-income households scheme, special focus is put on promoting efficient energy use in the residential sector. For tertiary sector (incl. public sector) the set of instruments includes financial incentives for the energy-efficient renovation of buildings and the sustainable construction of buildings, energy-efficient heating systems, and efficient electricity use, as well as green public procuremnet for public sector.

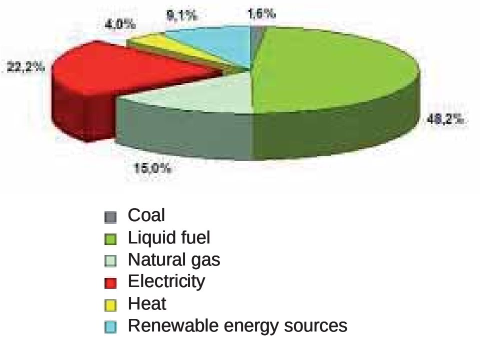


Figure XVI.iii: Structure of final energy consumption by fuel type, in 2005. (Source: SORS and NEEAP)

Building regulations

The Building regulation in Slovenia is unified for the whole country and developed under the Building Construction Act. The building permission is issued by the local offices of the ministry after the planning documentation is approved. The control of compliance with building regulation is done by Building Control Officers, operating under the ministry responsible for building construction, energy efficiency and the environment. During the design stage also other special acts (Energy Act, Environmental Protection Act and Spatial Planning Act) define the building energy efficiency and CO_2 emissions.

In Slovenia the EPBD was transposed into the national legislation by Building Construction Act (Official Journal RS, Nr. 102/04, 21st September 2004) (art. 3, 4, 5.1, 6), Energy Act and its amendments (Official Journal RS, Nr. 27/07, 26th March 2007) (art. 5.2, 7, 9, 10) and Environmental Protection Act (Official Journal RS, Nr. 41/04, 22nd April 2004) (art. 8, 10). The following secondary legislation (regulations) covers the detailed provisions:

Regulation on efficient use of energy in buildings (Official Journal RS Nr. 93/08, 30th September 2008) covers the article 3, 4, 5.1 and 6 of the EPBD, and thus defined the calculation methodology and minimum requirements for new and existing buildings in case of major renovation.

Regulation on methodology of feasibility studies of alternative energy systems in buildings (Official Journal RS, Nr. 35/2008, 9th April 2008) covers art. 5.2. It defines the methodology of feasibility studies and the necessary indicators for the evaluation of alternative options. Feasibility study of AES is an obligatory part of detailed design documentation submitted to the local authority for the building permit (according to Building Construction Act).

Regulation on energy certification of buildings (art. 7) has entered the public consultation process in beginning of November 2008. It defines the methodology of energy certification of new and existing buildings, of residential and non-residential buildings in case of sale, rent and public placement. It determines when asset and operational rating is to be applied. It also defines the electronic data base of energy certificates.

EPBD implementation

Calculation method

Calculation of energy performance of building for the purpose of showing the compliance with the minimum requirements is done (a) based on SIST EN12831:2004 for specific heating power demand (W/m^3) and on VDI 2078:1996 or ASHRAE for specific cooling power demand (W/m^3); (b) while for checking the energy use of a building the calculation can be done either by a simplified method (before mentioned (a)) or by SIST EN ISO 13790 (details are available in Regulation on efficient use of energy in buildings, from September, 2008).

The SIST EN ISO 13790 based calculation method (with national boundary conditions) is used also for building energy certification.

The respective software is being developed by various market actors (one tool finished, the next one in progress). Additional effort was put in preparation of climatic data (climatic data available in 1 km mesh since 2007), due to the considerable regional variety in climate.

Energy performance requirements

Definition of minimum requirements is a part of Regulation on efficient use of energy in buildings (accepted in September, 2008). The minimum requirements are expressed in terms of maximum allowed transmission heat losses, ventilation heat losses and/or power of devices for heating (transmission and ventilation) of building; maximum allowed specific cooling load and/or power of cooling system, requirements for obligatory installation of RES devices (min. 25% of total power demand must be covered by installation of RES systems). RES requirement is considered to be fulfilled also by installation of solar collectors for hot water (min. 6 m^2/residential unit), installation of PV panels min. 5 W/m^2 of building and by implementation of ice storage for cooling. It is obligatory to prepare a "list of thermal characteristics of the building", where the main system characteristics and simplified estimation of energy use is given.

Additional requirements refer to maximum U values of building envelope and windows (for walls 0.28 W/m^2K, partitions between flats 0.90 W/m^2K, flat roof 0.20 W/m^2K, windows 1.3 W/m^2K, doors 1.8 W/m^2K) and to air tightness of the envelope.

A considerable list of requirements refers to energy efficiency characteristics of installations. Heat recovery in ventilation must be used due to strict requirements for maximum allowed ventilation heat losses. The minimum required heat recovery in ventilation and/or AC systems is 65%. Individual electrical heaters for domestic hot water are not acceptable unless economically reasonable. Low temperature heating systems (max 55°C) as well as condensing gas boilers are obligatory in new buildings. Heat and cold must be metered per particular unit.

Additional requirements for cooling refer to obligatory shading of the envelope and to requirements for cooling systems.

Minimum requirement for lighting defines maximum allowed power of lighting devices per building category. Energy saving lamps are obligatory, only 20% of lighting may be covered by incandescent light bulbs.

Minimum requirement for primary energy is expressed by reference building approach. Minimum requirement is given also for final energy needed for space heating with preparation of domestic hot water as well as for cooling.

The energy indicators (power of HVAC and electrical devices, primary energy for heating, DHW, cooling, AC in kWh/a and kWh/m^3a (kWh/m^2a for residential buildings), % of RES using installed power, CO_2/a and CO_2/m^3a) have to be summarized in the "list of thermal characteristics of the building" for design stage and for actual stage after the building is finished. Fulfilment of minimum requirements has to be demonstrated in designs for building permit, and when the building is built, when applying for permit to use the building.

Energy performance certificates

The amended Energy Act (Official Journal Nr. 118, 17th November 2006) defines the framework conditions for energy performance certificates (EPC).

Certificates for new buildings and public buildings are obligatory since 1st January 2008. Large public buildings have to provide EPCs and public placement of certificates in the period from January 2008 by December 2010 latest.

EPC can be issued either for a part of the building (flat or non-residential unit) or for a whole building. By the law EPC has a status of public document, so it can only be issued by authorized companies and elaborated by licensed experts.

Regulation on energy performance certification of buildings defines the methodology of energy certification of new and existing residential and non-residential in case of sale, rent and public placement. It determines when asset and operational rating is to be applied. Asset rating certificate is considered for new buildings, existing residential buildings (based on SIST EN ISO 13790). Operational rating certificates are foreseen for other buildings.

Energy efficiency classes are foreseen in asset rating, based on the energy demand for heating, where 7 classes A-G are defined. Final energy and CO_2 indicator calculated out of primary energy demand are presented on the front page of certificate, by colorful scale. All three indicators are given equal importance.

Operational rating certificate is considered for existing non-residential buildings (based on SIST EN 15603). The core indicators in operational rating are:

- final energy for heating (kWh/m^{2}a),
- electricity consumption (kWh/m^{2}a) and
- CO_2 indicator (kg/m^{2}a).

In case of existing buildings planned for sale and public buildings, energy efficiency measures are obligatory enclosure to the certificate.

Inspection of systems

Regular inspection of boilers is done by chimney sweeping service. Slovenia has decided that instead of one-off inspection of heating installation the option b) will be applied by provision of advice (national energy advisory network ENSVET) to owners on replacement of boilers and modifications of heating systems.

Regular inspection of air-conditioning systems is defined in the Regulation on regular inspection of air-conditioning systems (Official Journal RS, Nr. 26/2008, 17th March 2008). The period of inspection is every 5 years. Phased implementation is planned depending on the age of the air-conditioning systems.

Other initiatives - incentives

Since 1995 Slovenia has carried out a large number of promotional programmes aimed at removing the barriers preventing an increase in energy efficiency and greater use of renewable energy sources. In addition, numerous regulations have been adopted primarily in relation to the energy performance of buildings and to household appliances and other products.

The main areas covered by the promotional programmes are:

- informing, raising the awareness of and training energy consumers, investors and other target groups;
- providing energy advice to the public;
- promoting the implementation of advisory services;
- promoting investment in efficient energy use and RES.

The main financial instruments are:

- allocating grants from the national budget or provided subsidised-interest loans for investments;
- ensuring favourable purchase prices (feed-in tariff) for electricity produced from renewable energy sources or high-efficiency cogeneration of electricity and heat from fossil fuels;
- providing exemptions from CO_2 pollution taxes in the implementation of certain measures.

More specifically, currently the following instruments are available for building sector (representing the first step of NEEAP):

- Subsidies for use of renewable energy sources in households,
- Subsidies for energy efficient retrofit of existent multi-apartment buildings (of at least 9 apartments);
- Eco-loans for citizens and legal entities for implementation of RES and RUE measures;
- Subsidies and soft loans for building owners and investors for construction of very energy efficient buildings.

Case study 1: Condominium

The case study describes the large residential building Condominium located in suburbs north of Ljubljana. The investor and the designer team Projekta have defined ambitious targets for large residential building of condominium type, regarding high quality of life in the building, comfortable floor areas of flats, recreating facilities, swimming pool, sauna, a lot of green areas in the surroundings, atrium with medium sized trees, high level safety and security standards, independent control of thermal comfort parameters in each flat and above all low energy building standard, with use of renewables and as well as with focus on optimization of investment and running costs.

Figure XVI.iv - Condominium Komenda building. (Source: Projekta, d.o.o)

The Building

The residential building is composed of 2 wings, each one with 4 storey and penthouse flats on the top, with the underground level, a common garage, wellness centre with a swimming pool. 138 flats are planned, with 11.500 m^2 net floor area. The building will be located in the green area of Ljubljana suburbs.

Building structure and envelope: Concrete load bearing structure is planned, i.e. concrete load bearing walls horizontally connected with concrete plates. Also the outer envelope is envisaged to be made of concrete with external thermal insulation. The optimization of the thickness was subject of consulting process during early design stage and resulted in 20 cm of expanded polystyrene external insulation on the walls (Uwall=0.172 W/m^{2}K) and 26 cm on the roofs (Uroof=0.176 W/m^{2}K, Ufloor=0.176 W/m^{2}K). The aim of the investor was to obtain high ranking in energy performance certificate and to reduce the energy costs. Optimisation of the thermal envelope, openings, glazing; optimization of final energy and costs, demonstrated relatively high investment in triple glazing, therefore double glazing with very well thermally insulated window frames were selected (Uwin=1.35 W/m^{2}K). Average thermal transmission of the whole envelope is Um=0.047 W/m^{2}K.

Energy concept

HVAC installation: Several scenarios were investigated in the consultation process: (0) gas condensing boilers, split AC systems, floor heating, natural ventilation, (1) heat pumps geothermal (72) – central preparation of heat and cold, distribution of heat by water media, distribution of cold by air in the ventilation system, mechanical ventilation with heat recovery, recovered heat is used for space heating / cooling; (1a, accepted) reduced nr. of geothermal probes (40), (2) gas boiler and heat recovery in ventilation and (3) additional heat recovery of heat in sewage.

The target is low energy building standard, supplemented by the optimization of the thermal envelope, openings, glazing; optimization of final energy and costs, interest in use of renewables. Heating /cooling is planned by floor heating, ceiling convectors for heating and cooling, central preparation of heat and cold, low temperature system, central exhaust air heat pump for preheating of DHW, geothermal probes (40).

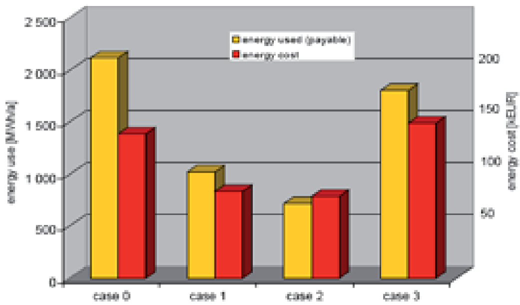
	case 0	case 1	case 2	case 3
	kWh	kWh	kWh	kWh
Energy	**4.317.550**	**2.443.200**	**1.612.600**	**5.087.550**
Heating (gas)	1.880.000	768.000	485.000	564.000
Electr & Cooling	177.000	288.000	204.000	1.257.000
Primary energy	**2.260.550**	**1.387.200**	923.600	3.266.550
CO2 emissions kg CO2	**507.410**	**321.600**	**214.820**	**790.290**
Primary energy kWh/m2	**197**	**121**	**80**	**284**
CO2 emissions kg CO2 /m2	**44**	**28**	**19**	**69**

Table XVI.ii - Energy indicators of the entire building complex per useful m2 of floor area of flat. (Source: EIE Coolregion)

Cooling concept: External screens are planned at the outer level of balconies that are 1.70 m deep and serve as overhangs. Envelope insulation is high, close to between low energy and passive house standard, so heating of thermal mass form outside is prevented. The windows have good U value (window and frames (Al needed for static reasons) at least 1.1 W/m^{2}K). Cold is produced centrally and distributed to the flats according to the use.

LCC calculation

Four LCC cases were calculated for this building. For LCC in early design stage the strategic LCC is appropriate. The data were taken from the data base (under development in EIE LCC DATA project).



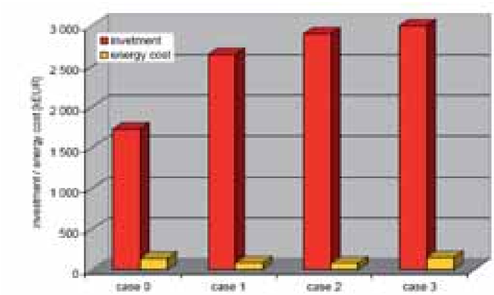


Figure XVI.v - Energy use vs. costs (above) and energy investment vs. yearly costs (below) for various cases. (Source:TST, d.o.o., EIE Coolregion)

Due to currently small sample of residential buildings in the data base at this stage, the cost used for LCC may rather illustrate the method than be fully representative. The energy data are calculated more in detail for the above defined scenarios (0-3). Such approach reflects frequent situation in practice, where more important costs are calculated / simulated more in detail. Modified case 1 was selected, with support of LCC calculation.

Key environmental features

Optimisation of the design was done in the frame of EIE Coolregion project (www.coolregion.eu, www.coolregion.info) Bellow the measures accepted during the consultancy in EIE Coolregion pilot project are summarized.

Urban design

- Optimal orientation of apartment NE (northeast), SW (southwest),

Landscape architecture and design

- Flat green roof and intensive greenery
- 64 % of greenery,
- Water scenes,
- Children's playground.

Architectural Elements

- Thermal mass in a load bearing structure,
- Thermal envelope ETICS with 20 cm expanded polystyrene on walls and 26 cm on roof,
- Larger glazed areas, shaded by fixed overhang in loggias,
- External sunscreens, movable,
- Natural shading by trees in atrium.

Technical Elements

- Vertical geothermal heat probes (the first application in residential sector in Slovenia)
- Geothermal heat pumps, connected to heat recovery of exhaust air
- Low temperature floor heating and ceiling convectors, activated thermal mass
- Built-in installations steered by a central control system

Case study 2: Social housing renovation Steletova, Ljubljana

Housing Fund – public fund of Municipality Ljubljana (280,000 inhabitants) – JSS MOL is owner of 3200 flats. In general the flats are in buildings with mixed ownership, where difficult decision making is a key barrier for energy renovation. The apartment block Steletova is 100% owned by JSS MOL. The tenants are low income tenants, where paying the operational costs may become a problem and if not payed – it becomes additional buden for Ljubljana Housing Fund. The Fund has decided for energy efficient renovation of existing buildings and selected Steletova building as a case study. The case study aims to demonstrate post-evaluation of energy efficiency and low carbon renovation project (completed in summer 2007), using also LCC analysis.

The Building

Steletova 8 building has got 3,800 m^2 of net useful floor area and 60 flats.

Status before the renovation:

- Wall 17 cm concrete + 5 cm TI
- Ceiling 8 cm TI
- Windows 2-gl. U=2.7 W/m2K
- Heating need QNH = 75-85 kWh/m^2a
- District heating for space heating

Figure XVI.vi - Steletova – before and after renovation. (Source: JSS MOL)

Planning passive house level renovation:

- additional thermal insulation (15 cm, roof 22 cm)
- Windows 2-gl PVC U=1.5W/m^2K
- adjustment of heating system
- mechanical ventilation in main rooms, 75% heat recovery; (old ventilation ducts still in bathrooms and kitchen),
- External shading
- Partial renovation of heating system
- Target heating need QNH < 15 kWh/m^2a
- Simpified calculation of energy demand; no scenarios, investment costs estimated, lowest prize tender for execution of works selected

Energy and CO_2 calculations

Energy calculations were done using PHPP simulation package, according to the boundary conditions in the national regulation. The following cases were evaluated and compared with measurements of before / after case.

Scenarios:

-VAR1: existing situation + no measures taken (theoretical)

-VAR2: existing situation; regular maintenance (replaced windows and facade when necessary due to the liefetime of elements, but no thermal improvement)

- VAR2a: as VAR2 but with actual energy consumption data (»before« in 2006/2007)

-VAR3: VAR2 + mechanical ventilation with heat recovery

-VAR4: renovation (low-e windows and wall TI), natural ventilation

-VAR5: renovation (low-e windows and wall TI) + mech. Ventilation (implemented)

-VAR5a: as VAR5 but with actual energy consumption data depending on users' behaviour (»after« in 2008/2009)

-VAR6: renovation: wall TI + windows replaced gradually, in 10 years

Scenarios	QNH (kWh/a)	CO2 emissions (kg CO2/a)
VAR 1	332.361	173.293
VAR 2	332.361	173.293
VAR 2a*	***244.990***	***127.738***
VAR 3	266.547	138.978
VAR 4	154.663	80.641
VAR 5	85.558	44.610
VAR 5a**	***181.150***	***94.452***
VAR 6	197.442	102.946

*measured »before 2006/2007«

** measured »after 2008/2009«

Table XVI.iii - Energy delivered for space heating calculated for scenarios (boundary conditions from regulation) and measured consumption before and after renovation.

Lessons learnt

The analyses showed teoretical expected energy and CO_2 savings of 74% (VAR5 vs. VAR1). The measured energy consumption demonstrated only 26% of energy savings (VAR5a vs. VAR2a). The envisaged reasons are: incomplete renovation of envelope in some areas, no mechanical ventilation with heat recovery in bathrooms due to technical barriers, inappropritate user habits (mechanical ventilation is always in use, no night set back temperature in use, resulting in higher internal temperature, the planned system of individual heat billing and metering has not been implemented yet).

Cases	Energy demand (kWh/m2a) for heating		CO2 emissions (district heating)
	Calculation PHPP	Measured	**(kg CO2 /m2a)**
PHPP before renovation	108		56,3
PHPP after renovation (mech. Ventil. & heat recovery	27		14,1
PHPP after renovation, inadequate user habits – open windows simulated	36		18,8
Before – measured 2006/2007		75	39,1
After – measured 2008/2009		55	28,7

Table XVI.iv - Specific energy demand and CO2 emissions for VAR 1, VAR5, VAR5a

As a part of post-evaluation LCC calculation was done for the above scenarios of building energy renovation and users' behaviour patterns. NPV of various scenarios is demonstrated in the figure in dependence of building life-time.

For the lifetime of 30 years the lowest NPV is obtained in scenario VAR4 and VAR6 (envelope insulation, windows, but no mechanical ventilation with heat recovery). For the life time of 60 years the most economically viable scenarios do not differ, but it can be also seen, that the investment in VAR 4 and/or VAR 7 pays out with the energy savings in comparison with the initial scenario VAR1 in 48 years (replacement of elements is needed after 30 years). The actually implemented scenario VAR5 that brings also better thermal comfort (not financially evaluated), has an average NPV value of € 1,172,425. If mechanical ventilation with heat recovery is not properly used (VAR5a) than the NPV of renovation measures is increased to €1,427,608.

The impact of different scenarios on investment vs. operational and maintenance costs is demonstrated in the last two diagrams; operational costs paid by the tenants are reduced to 30% in VAR5.

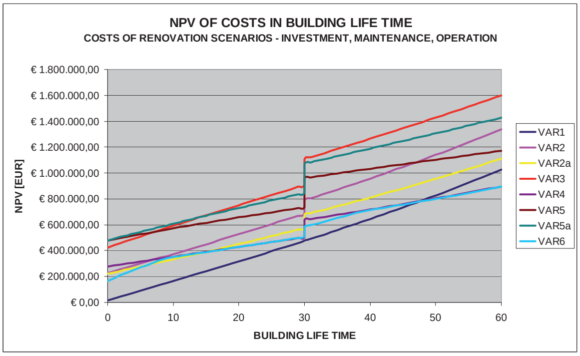
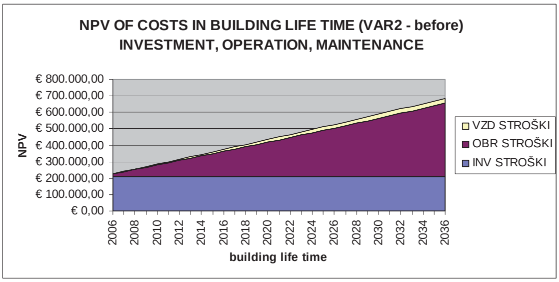
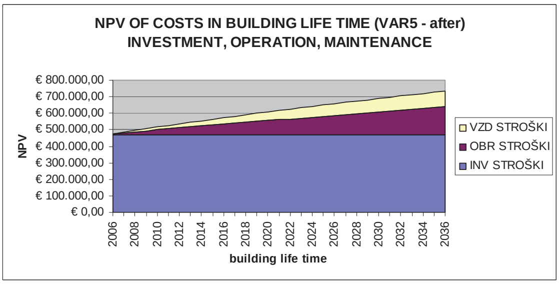


Figure XVI.vii - NPV of renovation scenarios in dependence of building lifetime, Steletova





Figures XVI.viii and XVI.ix - Development of operation (violet) and maintenance (yellow) costs in scenario before (VAR2) and after (VAR5) renovation

Steletova building was a pilot case of renovation of social housing according to low energy standards. In spite of some problems during the implementation the case study was an excellent experience for social housing sector and identified the code of practice for future actions.

Planning legislation

The Spatial planning act has foreseen three levels in spatial planning: (a) strategy of spatial planning, (b) spatial order and (c) spatial plan. In 2004 the Ministry for environment and spatial planning prepared National strategy for spatial development, based on the Spatial planning act. According to the above act the municipalities have to prepare municipal strategies for spatial development, while the development of regional strategy is an optional document. Detailed plans, i.e. spatial order and spatial plan are developed at municipal level. The process begins with the initiative, the 1st spatial conference, experts' groundwork and ends with proposal for detailed plan presented at the 2nd spatial conference, the corrected plan is then subject to public hearing and after public comments and political decisions turns into draft, which is sent to institutions for their opinion and consent. Detailed plans then represent legal background for location information and for issuing building permit.

In addition to spatial legislation it also important that according to the Energy act the municipalities are obliged to prepare the local energy plan with the focus to assure the energy supply and reach the environmental protection targets. The energy source at the building level has to be selected in accordance to the local energy plan; the selection of renewable energy sources is encouraged also with support of EPBD feasibility studies regulation.

Urban case study: Jesenice - building rehabilitation

Municipality Jesenice, a steel industry city in Slovenia, went through economic problems and political changes in the 1990s. Due to the Residential law the former rental flats in poorly maintained social housing stock were in 90% privatised, at a very low price, mainly by low income inhabitants. Over 80% of 304 existing big apartment buildings in Jesenice need intensive renovation, due to functional reasons, energy and environmental challenge and high running costs.

The city district heating company identified over 40 buildings (1400 flats) with delivered energy consumption for heating exceeding 150kWh/m^2a, where interventions are needed. As a part of EIE project EffCoBuild and in cooperation with local authority the measures, like website benchmarking, progressive subsidies and pilot energy certification of buildings, were prepared aiming to help the large residential buildings in Jesenice to develop sustainable maintenance and renovation projects.

Currently the total residential building stock area covers 546,500 m^2 , i.e. 60% of the stock, the non-residential building floor area is estimated at 364,300 m^2; i.e. 40% of the stock, and from that the public buildings floor area is 43,000 m^2. 58% of dwellings were erected in the period 1945-1980, and therefore exhibit high energy saving potential, due to the low insulation of the envelopes and old-fashioned HVAC technologies. Renewable energy sources come to the agenda but a break through for their wider implementation is still to be reached.

Figure XVI.x - Jesenice area

These technically based difficulties are combined with continuative decrease of steel production, decrease of workers income and consequently with lower capability of inhabitants to invest in maintenance or event energy efficient refurbishment of the building stock. In the last 20 years the environmental issues came strongly to the agenda of Municipality Jesenice. The environment, once polluted because of the industrial emissions, is being continuously improved. The emissions caused by low quality of buildings and low efficiency of heating systems have been systematically focused since 1999.

To complement the existing awareness raising activities and programmes of subsidies also additional programmes are needed to inform and teach the building owners and users about the energy efficiency and to stimulate the realization of energy savings through EE investments as well as through behavioral change, not neglecting more and more important public participation decision making

The central part of the municipality is heated by district heating. The town has the sixth largest (according to heat capacity) district heating system in Slovenia that covers 43% of demand in building sector. Around this area at the outskirts the natural gas network is being developed, that contributes 7% to the energy supply; while 48% of the building sector in more distant locations are supplied by oil, biomass and combined systems. In more scattered locations there are still the individual heat generators using coil. The reduction of the latest is planned, either to switch to natural gas or to use alternative energy sources (preferably wood biomass).

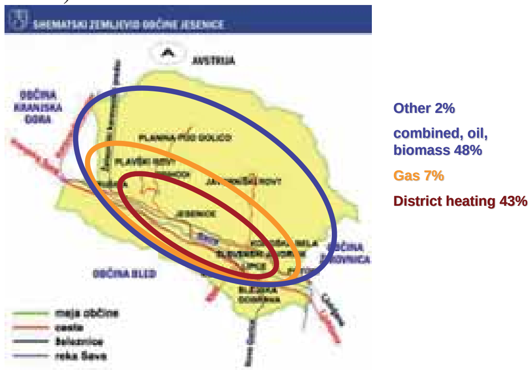


Figure XVI.xi - Jesenice energy networks. (Source: EIE EffCoBuild)

Energy and CO_2 savings

The estimated energy savings in residential and municipal housing stock could reach 45% (48,642 MWh /year) in case of implementation of the most important energy saving measures (envelope insulation, refurbishment of heating systems and heat generators, improved local and central regulation, hydraulic balance of the heating system, installation of thermostatic valves, heat metering and billing according to actual energy use). 30% of the identified energy saving measures exhibit the payback bellow 10 years.

In the case of the implementation of the proposed measures, the municipality Jesenice could reduce CO_2 emissions in the building sector by 8.4 million tones per year in single family houses, by 6.0 million tones per year in apartment buildings and by 0.6 million tones per year in public building sector.

Implemented measures

As a part of EIE project EffCoBuild and in cooperation with local authority the measures were prepared aiming to help the large residential buildings in Jesenice to develop sustainable maintenance and renovation projects. Measures are focused on financial, technical / social and environmental barriers to implementation:

- Progressive subsidies allocated from the municipal– budget; the subsidy depends on the energy consumption, and it can reach up to 30% of investment, for buildings with energy use over 230 kWh/m^{2}a.
- Energy service contracting was offered to 40 top apartment buildings – top energy consumers.

- Training of building management companies for– preparation of refurbishment projects was prepared, focused on a for successful support in financing, tendering, implementation and later management
- "Web-site benchmarking"; linking latest energy– indicators of 40 top energy consuming apartment buildings with indicators of best practice renovation cases.
- Energy certificates available on-line for 40 top energy consumers;
- Recommended scenario of building refurbishment (based on energy audit, incl. LCC assessment).
- IR thermography of 40 apartment buildings available on-line.

Website benchmarking

"Website benchmarking" is an umbrella name for a set of measures using internet for communication with the target group: building owners (incl. users, tenants) and/or building managers in order to stimulate the EE renovation projects in building sector in Jesenice and to facilitate the use of available municipal co-financing instruments and other national supporting instruments.

Currently, the biggest problem is to build a refurbishment project, i.e. to move from the identified energy saving potential to actual decision for the implementation of the measure. Internet was considered to be a powerful tool to bring the general information about the actual energy use, the actual building condition, the energy saving potential to the relevant target group (building managers, building owners, ESCOs, technology suppliers and building contractors). Communication with key actors through a home page of municipal district heating company JEKO-IN is used also to present energy performance certificates, thermographic pictures, available financial incentives, energy advisory options; as well as it is planned to disseminate the useful results of other EIE projects in the field of municipalities, social housing, energy certificates and passive house renovation.

Website benchmarking of delivered energy for 40 big apartment buildings in the centre of Jesenice, connected to district heating. and considered as big energy consumers in the heating season 1998/99 due to delivered energy above 150 kWh/m^{2}a, was developed. The data are available on the EffCoBuild section at JEKO-IN homepage (http://www.jeko-in.si/index.php?i=137).

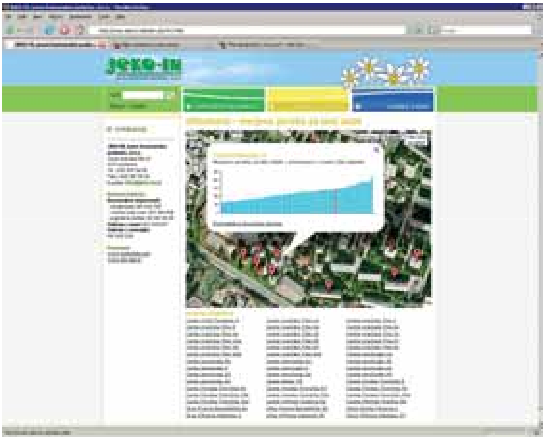


Figure XVI.xii - Website benchmarking of energy use for big energy consumers in Jesenice.

In addition all 40 buildings are presented also with pilot energy performance certificates, thermographic pictures and various energy indicators. A recommended scenarios of building refurbishment are based on energy audit results (financed by the municipality) and on life cycle thinking in planning of sustainable maintenance and refurbishment.

City case study: Ljubljana

Ljubljana is the capital of Slovenia with 280,000 inhabitants, which reaches nearly 0.5million inhabitants with daily migration. In Feb. 2009 the mayor of Ljubljana has signed the Covenant of Mayors and committed the city to reduce the emissions and to improve energy efficiency in all sectors.

Figure XVI.xiii - The city of Ljubljana

Ljubljana has implemented a number of activities in order to implement sustainable development and to reduce CO_2 emissions:

The strategy for sustainable development of Ljubljana was developed based on the SWOT analysis and contains:

- basic directions of current development of the city,

- the vision of development based on SWOT analysis expressed in two scenarios with core targets of development,
- eight development programmes with the concrete projects,
- proposals of projects necessary for successful integration with nearby municipalities in the region.

Ljubljana has elaborated the detailed Programme of protection of the environment with sustainable targets. According to the planning legislation Ljubljana prepared also a complex local spatial order and a spatial plan (still in preparation) oriented to sustainable development.

One of the well known and succesful green infrastructure projects in Ljubljana is "The path (POT)", a construction of a circular memorial park around the city of Ljubljana, bringing into a circle individual natural landscape features and green areas in the city. The path offers over 40 km of sports routes (walking, running, cross-country skiing, recreational cycling, relaxing in nature…), it acts as an area of significant environmental value and maintains a historic memory of a World War II Ljubljana, occupied and entirely fenced in by barbed wire.

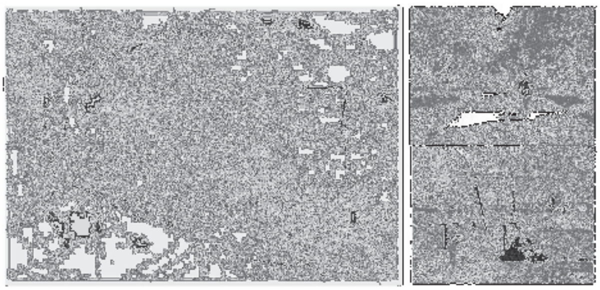


Figure XVI.xiv - Green infrastructure project in Ljubljana "The path (POT)". (Source: Grgic & Lenardic 2006)

National conclusions

In the period of COST C23 Action Slovenia made a significant move towards very low energy new buildings and energy efficient renovation of existing buildings. Slovenia has accepted ambitious minimum requirements in 2008, where also 25% of renewable energy sources are required at a building level.

In addition to that considerable financial resources have been allocated to stimulate investments (www.eko-sklad.si) in building renovation and in construction of very low energy and passive buildings. The scheme for financial incentives for public buildings based on cohesion fund is in preparation for the end of 2009.

The described activities are examples of many similar actions that are currently on-going in Slovenia with the target to reach Kyoto CO_2 reduction target, the improvement of energy efficiency from NEEAP and the 25% share of renewables at national level as defined in the Directive 2009/28/EC for promotion of use of energy from renewable sources.

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XVII Spain

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National context

General data

Spain is a sovereign country member of the European Union, constituted in social and democratic State of Right, and whose form of government is the parliamentary monarchy. Its territory, with capital in Madrid, occupies most of the Iberian Peninsula.

Spain has an extension of 504,645 km^2, being the fourth more extensive country of the continent, after Russia, Ukraine and France. With an average altitude of 650 meters on the level of the sea, is the second more mountainous country of Europe, after Switzerland. Its population is 46,063,511 inhabitants, according to data of the municipal register of 2008.

Energy situation

The power situation in Spain is characterized by three fundamental aspects:

- Great dependency from other countries (more than 77% in 2006)
- Cause an important aggression to environment (hard dependent of fossil fuels)
- Both growth of consumption and primary and final intensity.

Spain has duplicated its energy demand in less than 20 years, from 74 Mtep in 1986 to 142 Mtep in 2004 (Source: Energy in Spain 2004, Ministry of Industry, Tourism and Commerce). In order to achieve the magnitude of energy consumptions in Spain, consumptions of primary and final energy in the last two years (2005 and 2006) are showed following:

In 2006, Spain was already the second producer of wind energy of the world, behind Germany, with a capacity of 11,615 MW and having increased in the last Renewable Energies Plan 2005-2010 the objective of the wind energy up to 20,155 MW. Obviously the pending subject is to improve use of solar radiation in which Spain has an enviable potential.

(ktep)	2005	2006
Coal	21.183 (14,5 %)	18.149 (12,5%)
Petroleum	71.786 (49,2 %)	70.864 (49,1 %)
Natural Gas	29.120 (20,0 %)	30.039 (20,8 %)
Nuclear	14.995 (10,3 %)	15.669 (10,9%)
Hidraulic	1.682 (1,2 %)	2.198 (1,5 %)
Other R.E.	7.185 (4,9 %)	7.653 (5,3 %)
TOTAL	145.835 (100 %)	144.291 (100 %)

Fuente: Boletín Estadístico de Hidrocarburos, Cores.
Table XVII.i - Consumption of primary energy in Spain, years 2005 and 2006

Regarding to final consumed energy in Spain, the distribution is showed following according to the different power sources consumed in 2005 and 2006.

(ktep)	2005	2006
Coal	2.424 (2,3 %)	2.267 (2,1%)
Prod. Petroleum	61.780 (57,7 %)	60.973 (57,8 %)
Gas	18.119 (16,9 %)	16.631 (15,8 %)
Electricity	20.862 (19,5 %)	21.470 (20,4%)
Renovable	3.815 (3,6 %)	4.148 (3,9 %)
TOTAL	106.999 (100 %)	105.490 (100 %)

Fuente: Boletín Estadístico de Hidrocarburos, Cores.
Table XVII.ii - Consumption of final energy in Spain years 2005 and 2006

Here it has content another one of the objectives of the Plan of Renewable Energies 2005-2010 that establishes to reach 29.4% of electricity generation with renewable energies, considering that, as it is showed in the previous graph, right now they reach only 18.8 %.

In the transport sector, PER 2005-2010 also incorporates the objective to reach 5.75% of power consumption in transports with the use of bio-fuels.

Another one of the problems in Spain in energy issues, as it has been said in the beginning, is Spain's high power dependency, that is near 80%, far away from

European average (50 approximately %). Following it's showed Spain's self-supplying from different power sources. It seems clear that bet to power saving and renewable energies will help to reduce external dependency, to reduce power consumption and therefore CO_2 emissions.

%	2005	2006
Coal	31,3	33,6
Petroleum	0,2	0,2
Natural Gas	0,5	0,2
Nuclear	100	100
Hidraulic	100	100
Other R.E.	100	100
TOTAL	21,1	22,1

Fuente: SGE
Table XVII.iii - Degree of self-supply

Atmospheric situation

Emissions of GEI (Greenhouse gases) to the atmosphere in Spain from year 1990 to the present time keep on increasing. In the 1990-2005 period the carbon dioxide emissions have increased in 52.2 %, surpassing in 37.2% the objective that must reach Spain according to the Kyoto Protocol ratified by the European Union: increase no more than 15 % of GEI's emissions from the base year.

By sectors, in 2006 energy processing supposes the greater responsible for emissions representing 78.9 % of total, therefore there is a correlation between power and CO_2 emissions. Thus the previous section of the power situation is bounded to the situation of GEI emissions. The industrial processes suppose 7.64 % of the emissions, agriculture 10.96 %, treatment and elimination of waste 2.83 % and use of solvents and other products 0.35 %.

The Spanish Government has approved, stimulated by the Environment Ministry the 2007 Spanish Strategy of Air Quality of the Air, with an orientated character and that will serve as reference for performance in this subject.

EPBD implementation

Energy overview

Spain is a country power employee having to concern most of the power sources. The objective in agreement with the PER (Plan of renewable energies) is that in 2010 12.1% of the consumption of primary energy will be supplied by renewable energies.

The climatology in Spain is so interesting from the energy point of view but has not been taken advantage, occurring the paradox that other European countries with less solar radiation have installed greater solar panels.

Structures and processes

The general legislation for the adaptation of director EPBD to the Spanish legislation it depends on the central government being to emphasize the recent publication of the CTE 29th March of 2006. In one of its sections the reduction of the CO_2 emissions is approached by means of the buildings power demand limitation.

Also another RD has been published in which is defined the system to describe the energy consumption of the buildings. In this case the pursuit and control of this label it is into the hands of the independent regions which can give rise to different exigencies and interpretations.
The third aspect of the EPBD adaptation is the necessity of a regulation that fixes the form and way to act in the facilities periodic inspections to verify its suitable yield. This new RITE that will replace the effective one has not been published at the present time.

In summary the general legislation is responsibility of the central administration although his interpretation and development it will be competition of the CCAA which will possibly give rise to very different casuistries.

The projects must be visas in the respective professional schools having to compliment the power demand limitation requirements with the simplified option (calculation of the transmission coefficients of the respective closings which they do not surpass a certain value) or by a computer science program.

In the future building power qualification, the project will be reviewed by the official organisms or credited organisms giving a qualification (A, B, C etc) to the project. After that, the power qualification will be verified during the construction of the building by an official organism. The procedure (number of inspections, tests to make, yield of the equipments, etc) to follow is not defined and it depends in each independent region.

Adoption of a calculation methodology

For the fulfillment of the building power demand limitation the Spanish norm contemplates two methods.

The first one consists of comparing the transmission coefficients of the closings with maximum values depending on the climatic zone. Alternatively, a computer science program can be used. The program name is LIDER. This program is applicable in the national scope although it is possible to validate other programs whose results are similar.

For the building power certification it can be used another simplified option (in this case the project can not obtain a superior classification to C) or a computer science program called CALENER. In this case also other programs can be used that must previously be validated.

Setting of energy performance requirements

The fulfillment of the energy demand limitation requirements is obligatory for the new construction buildings and the reforms of existing buildings with a useful surface superior to 1000m^2 or when more than the 25% will be reformed. It is not applicable in opened constructions, protected buildings, provisional constructions, cult places, industrial buildings and isolated buildings with a surface smaller than 50m^2.

The fulfillment of the energy saving requirements in the illumination is applicable to all the new construction buildings, reforms of the existing buildings with an useful surface superior to 1000m^2 where more than the 25% of illuminated surface will be reformed and the administrative and commercial buildings in which the illumination installation will be reformed.

The fulfillment of the Sanitary Hot Water production requirements is indispensable for all buildings and conditioned swimming pools (new construction and rehabilitation of the existing ones).

The fulfillment of the requirements of the electrical energy production through photovoltaic solar panels is only indispensable in buildings with different uses and from a determinate surface.

The new norm demands, like already has been indicated, the implantation of facilities that allow to limit the fossil fuel consumption. In the design of the building must be considered this implantation to make possible the positioning of solar panels and, if it is required, photovoltaic panels. The solar contribution to the SHW will depend on the climatic zone. Greater demand and better climate zone will mean greater solar contribution will be needed.

For the existing buildings special requirements are not contemplated. Nevertheless in the case of reform or rehabilitation, it will be needed to limit the energy demand and to have an energy building power qualification.

Energy performance certificates

The methodology to obtain the power qualification responds to national criteria indicated in RD 47/2007, 19th of January. This program calculates the primary consumption of energy consumed in kWh/year and the CO_2 emissions expressed in kg/CO_2/year.

Independent experts

The project certificate of power efficiency and the finished building certificate of power efficiency are subscribed by the designer of the building. In addition, each CCAA will establish the inspections to make and who can make them (authorized control organisms).

Integration of new measures with existing legislation

The new legislation replaces the NBE-CT (1979) being the main newness the requirement of greater isolation of the closings and thermal bridges. The requirements of photovoltaic electric energy production, energy saving in illumination and sanitary hot water production are completely new. The last one was already in some municipal norms. Also the power certification requirement of the buildings is completely new.

Case study 1: New Construction Building

Context

This study case is about a project of 69 single-family houses located in Paterna (Valencia). The promoter is INNOVA and it is dedicated mainly to the promotion of houses and buildings being a widely concerned company with the sustainable development of its buildings.

Paterna is located in the province of Valencia, in the Southern east of Spain. Its population is 54,560 hab. The climatic severity of the city corresponds to the B3 classification, in agreement with the CTE-HE-1. The altitude of the town with respect to the capital of the province is 70 meters.

The Building

There are different types of houses inside the promotion. The house that has been chosen for the study is denominated as B3 type. One is an isolated house that consists of ground floor +1 in addition to a plant cellar. Characteristic data are the following ones:

- Useful surface plant cellar: 29.88m^2
- Useful surface ground floor: 58.65 m^2
- Useful surface first floor: 57.14m^2
- Total constructed useful surface: 145.67m^2
- Nº of bedrooms 3
- Nº of bathrooms: 2
- Kitchen, hall and toilet.

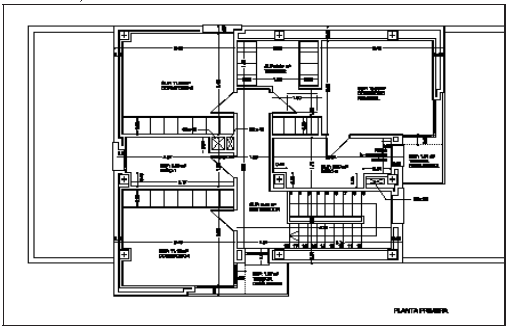

Figure XVII.i - First floor of the New Building

The usual materials in this zone of Spain have been used being the most outstanding the following ones:

- Closing of brick factory
- Reinforced concrete structure
- Isolation LV

Actually the building was conceived initially without greater pretensions from the point of view of the sustainability. The fuel used for heating and ACS is natural gas. The heating and hot water ACS are produced by means of individual mixed boilers. The air conditioning with independent equipment for each house using electrical power. As support to the HWS production, solar panels are going to be installed.

Performance criteria

The project studied would not have to meet compulsory the requirements of the new Spanish legislation on the limitation of the power demand.

Decision making

Promoter has decided, in a voluntary way, to apply the new exigencies of limitation of the established demand of energy in the new CTE. This means a sensible increase of the isolations of surrounding thermal of the building.

The promoter also settles down as an objective to obtain a minimum power qualification of C. In agreement with RD 47/2007. The architect has decided to increase thickness and quality of the isolation.

Cost analysis

As consequence of the introduced improvements it has been evaluated the monetary cost and the saving obtained during the building operation as consequence of the smaller power demand.

Key points

Based on the results we can conclude the following:

- The investment economic increase for improving the isolation of the building supposes €1586.90 that would be amortized in a period of time of approximately 25 years.
- The increase of the CO_2 emissions in the phase of manufacture of the materials is 9582.17 kg that would be amortized in a period of time of approximately 19 years.
- If we consider the useful life of buildings it is observed that the conducted modifications are profitable although it would be possible to improve choosing materials of smaller energy "in body". In our case expanded polystyrene EPS presents in front of the glass wool a worse behavior (factor of superior emission 10 times).

Case study 2: Refurbishment Building in Madrid

Context

This study case is about the refurbishment of a building of 4 dwellings, two of them in the first floor and two in the second floor. In the ground floor it's located a zone destined to garage.

The refurbishment consists in increase the number of dwellings to 7; 3 in the first floor, 3 in the second floor and a new one on the penthouse that is going to be built over the existing building, maintaining the ground floor as a garage. The building is located in the Amalia street of Madrid. The climatic severity of Madrid corresponds to the D3 classification, in agreement with the CTE-HE-1. The promoter is a small company specialized in buildings refurbishment.

Building

The surface of each original floor is 111.62 m^2 (ground, first and second) being the one that is added of 54.5m^2.

The usual materials in this area of Spain have been used in this case, being the most outstanding the following ones:

- Closing of brick factory
- Reinforced concrete structure
- Isolation polyurethane foam

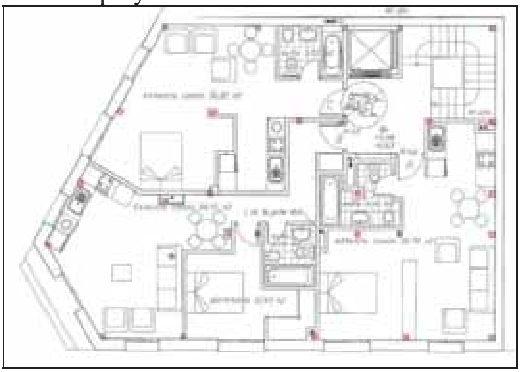

Figure XVII.ii - First and second floor of the Refurbishment Building

It is a building initially thought without greater pretensions from the point of view of the sustainability. The main aim is to increase the number of dwellings and to adapt them to the new necessities that the society demands including the conditions of comfort.

Originally the dwellings had an electrical heating that has been replaced by one of radiators by hot water produced by a mixed natural gas boiler. As support to the ACS production, solar panels have been installed.

Performance criteria

The refurbishment project study did not have legally to meat the requirements of the new Spanish legislation on the limitation of the power demand. The original project was made in agreement with the existing standard in its moment (NBE-CT-79) being the maximum coefficients of transmission demanded those that correspond to the climatic zone "Y" in agreement with the NBE-CT-79.

Decision-making

The promoter has made up his mind, in a voluntary way, to apply the new exigencies of limitation of energy demand in the new CTE. This means a sensible increase of the isolations of surrounding thermal of the building.

Cost analysis

As a result of the introduced improvements it has been evaluated the cost and the saving obtained during the building operation.

Key points

In a nutshell we can conclude the following:

- Increase of the CO_2 emissions in the phase of manufacture of the materials is 52,245.05 kg that would be amortized in a period of about 11.6 years.
- According to the new standard "HE1" the former building would be classified as "E"
- After the improvements of isolation in the phase of refurbishment the building is classified "D"

Low carbon planning legislation at a national level

Current situation

The European Community ratified the Kyoto Protocol in 2002 as result of the 2001 European Climate Change Program. So, Europe, as a whole, acquired the commitment to reduce the emissions of the Greenhouse gases ("Gg") in 8%. This percentage is a global reduction distributed among each country which has different rates. Spain committed of not exceeding in more of 15% its emissions of Gg with respect to the emissions of the year base.

In Spain, the importance of the energy sector is up to 78.21 % of the CO_2 emissions. Therefore, the measures for reducing the emissions focus on an accuracy management of the energy: control of power demand, power saving and efficiency and increase of the renewable energies.

On the other hand, the waste management (treatment and elimination) supposed a 2.83% and the industrial processes was a 7.64% of the emissions of Gg in Spain in the 2004. These factors and power greatly influence to construction sector. Agriculture also supposes a high percentage (10.96%), while using dissolvent and other products only represents a 0.35%.

There is a constant growth of emissions to the atmosphere in Spain. In 2004, the increase has been of 47.87% compared with the year base, and in the 2005 it increased a 52.2% which implies an excess of 37.2% from the Spanish commitment according to the Kyoto Protocol (Figure XVII.iii).

Therefore, the main goal in Spain is to reach the acquired commitment with the Kyoto Protocol. So, Spain has elaborated a great number of Plans and Strategies in order to reach the committed objectives in 2012.

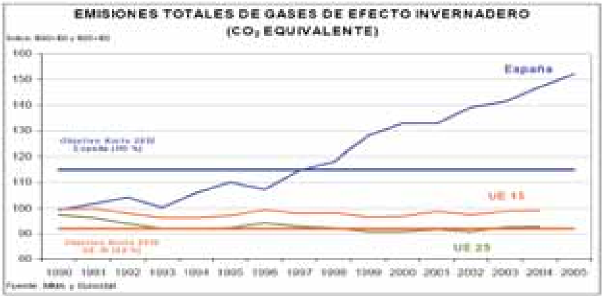

Figure XVII.iii – Gg emissions - Kyoto Target

The "energy intensity", measured as energy consumption per unit of GDP, is a good indicator. Thus, for the case of Spain, in the period from 1995 to 2005 the evolution of the energy intensity is as follows.

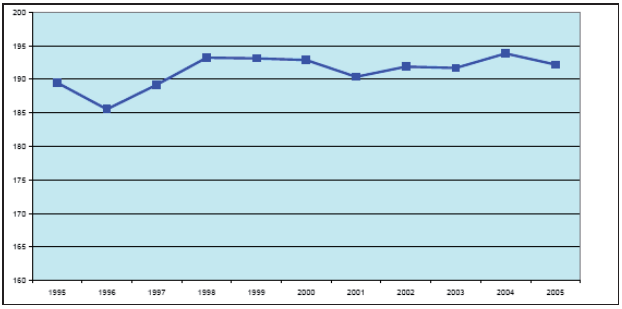

Figure XVII.iv - Energy intensity (primary energy per GDP unit)

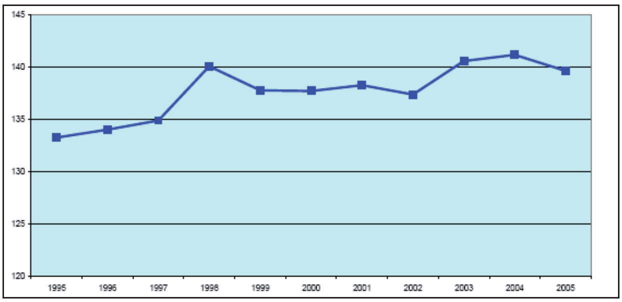

Figure XVII.v - Energy intensity (final energy per GIP unit) Source: NPA 2008-2012

Recent emissions trends

The energy consumption in Spain is expected to change substantially until 2012, mainly due to the economic evolution, the new technologies, the industrial development. Because of an increase of the power consumption is expected, the Spanish future will support on power saving and efficiency (according to Green Book on the Power Efficiency or How to do more with less, by the Commission of European Communities 2005) with the objective to reduce the power losses, to increase the percentage of renewable energies over total, to improve the formation and information to the final consumer within the context of a liberalized market assuring rational and efficient a consumption the energy and stimulating economically projects which support the reduction of emissions or power consumption.

The consumption of final energy in Spain in the period 2008-2011 is estimated that will grow a 2.4% per year, the primary energy up to an average rate of 2% between 2005-2011, while the demand of electrical energy will increase to a rate of 2.5% between 2007-2011, which supposes to approach its annual growth to the forecasted GDP growth (Source: NPA 2008-2012).

Due to the acquired commitment by Spain to reduce the Gg emissions to 15% compared to the year base, the policies focus on the following three issues:

- To stimulate economically the reduction of emissions, by valuing the ton of carbon dioxide (carbon market), by means of the "flexible mechanisms" of the Kyoto Protocol, supporting and financing projects that suppose a power or emissions reduction and supporting the research (I+D) in the country.
- To support the power saving and efficiency by establishing new lines of investigation, improving the existing technologies to reduce the losses and increasing the yields of the equipment and liberalizing the electrical sector.
- Finally, to increase the Renewable Energies in a country like Spain where the Aeolian, solar and hydraulic resources can become very important.

National policies and measures related to CO_2 emissions

A key issue for the reduction of the CO_2 emissions is the National Plan of Allocation of rights of emission ("NPA") 2008-2012. The Spanish NPA objective is that the total emissions of Gg are not higher of 37% from the year base. In order to obtain this objective, it is expected that, due to the measures of the Strategy of Power Saving and Efficiency 2004-2012, industrial sector only increases 37% while the diffuse sectors foreseen an average increase of 65%. Therefore, new measures for the reduction arise from these sectors, as we mentioned below, with the objective of not surpassing the 37% that it establishes as objective base the Spanish National Plan of Allocation.

Anyway, although this objective of 37% would be got, there are another 22 points to reduce to get the committed objective by Spain to reach a reduction of

15% of emissions (Kyoto Protocol). So, NPA 2008-2012 raises the possibilities of reducing in a 2% the emissions by means of carbon drains, and a 20% by means of the "Flexible mechanisms" established by the mentioned Protocol.

To get these objectives, the Ministry developed the Strategy of Power Saving and Efficiency in Spain 2004-2012 (E4) that established savings of final energy (41,990 ktep), savings of primary energy (69,950 ktep), non emitted carbon dioxide (190 millions of ton) and reduction of primary power intensity in 7.2% in period 2004-2012, by means of measures in all the sectors:

- Sector transport: by means of plans of mobility, promotion of the public transport, renovation of the fleet, more efficient use of the transport.
- Sector buildings: by means of the implementation of European Directive EPBD of Power Efficiency of buildings that result the Technical Code of the Construction that establishes minimum requirements of the isolation of the buildings (HE-1), of the yields of the thermal facilities (HE-2 - RITE), of the illumination within the buildings (HE-3), establishing minimum contributions to the sanitary hot water - ACS- by means of thermal solar energy (HE-4) between 30% and 70% depending on the climate zone of Spain, and minimum contributions of electrical energy to pave photovoltaic for those buildings with great power demands (HE-5). In addition, the Power Qualification of the buildings according to its power consumption also settles down during the phase of use of the building. The take into effect of the Technical Code of the Construction will suppose for each building a power saving of a 30-40 % and one reduction of CO2 emissions of a 40-55%.
- Industry sector: improving the efficiency of the technology, by means of monitoring and control.
- Services and Residential Sector: promotion of household-electric of Class A, by means of the formation and information of the users.
- Public services sector: reforming the public lighting system and improving the potable water provision.
- Agricultural Sector: modernization and technological improvement.
- Energy Sector: increasing the efficiency and the optimization of the technologies of power generation.

Nevertheless, in certain sectors and seeing the power tendency, the revision became necessary of previous the E4 Strategy, elaborating the present year the 2007 Plan of Action 2008-2012 on the Strategy of Power Saving and Efficiency in Spain, establishing objectives of reduction of the primary energy of 24,776 ktep in 2012 (13.7% of year 2004) and reduction of the 238,130 kton CO_2 emissions in period 2008-2012. This way, the Directive 2006/32/CE who settles down the measures for a power saving of 9% for year 2016 according to the trend scene that would turn out to consider the consumption power of last the 5 years. With this one Plan of Action would obtain 11% in the 2012. With this new Plan, the diffuse sectors suppose more of 75% of the new investments.

The third important factor in the policy of reduction of carbon dioxide emissions are the Strategies of the Renewable Energies. Thus, it is the Plan of Promotion of the Renewable Energies 2000-2010 whose objective was to cover with renewable energies the 12% of the total energy consumption in 2010. In 2004, in the middle of the period, it is analyzed that certain deviations with respect to the objectives of each renewable energy in individual exist becoming necessary the revision of the Plan, and being generated the new Renewable Energies Plan (REP) 2005-2010 that maintains the objective of 12% but incorporating two additional objectives: 29.4% of the electrical generation produced by renewable energies and 5.75% of bio fuels in the sector transport.

As frame of all these processes is the Spanish Strategy of Climate Change and Clean Energy, Horizon 2007-2010-2020 establishes the strategies to follow for a reduction of CO_2 emissions and by adding the concept of "adaptation" to the impacts of the Climate Change because it hopes that Spain is one of the countries where greater impact is going to generate. It means that it exist a change and a conscience not only to reduce the emissions but, besides, to adapt to the change seems inevitable.

Urban case study: Chamartin project (Madrid)

Short description

The following points are a short description of the urban case study selected:

- Location. Madrid
- Private initiative
- Area: 3,120,658 m^2
- Construction area above ground
- Lucrative: 3,280,000 m^2
- Non Lucrative: 1,100,000 m^2
- Buildability: 1.05 m^2c/m^2s
- Construction start: 2010
- Schedule: 10 years

Context and aims of the project

The main aim of the project is to build a new area dedicated to offices and dwellings close to the Chamartin railway station being necessary to leave the rails underground.

	Average scenario (%)	Maximum variability (%)
Residential	50	30/70
Office buildings	35	15/55
Other	15	13/49

Table XVII.iv - Distribution of uses and flexibility

Funding

Investment in public infrastructures:

- Urban infrastructures: €3,100 M
  within the limits of the project: €1,700 M
  outside the limits of the project: €1,400 M
- Rail infrastructures: €1,000 M

Decision making

Energy efficiency drivers:

- Public transport and improvement of mobility:
  - Public transport infrastructures: extension of two underground lines with 6 new stations; 2 new suburban train stations; 3 reserved platforms for buses; 2 modal interchangers; extension of Chamartín railway station (high speed train) and its connection to Barajas airport and Atocha railway station.
  - Other transport infrastructures: 5 transversal streets; new access to the city (Castellana extension); closing of the M-30 peripheral road.

Castellana extension project improves the mobility of all the northern metropolitan area of Madrid, saving 12 M hours/year (≡ €120 M/year).

- Urban design:
  - Office and other tertiary buildings have been localized in the proximity of underground and suburban train stations.
  - Distance from employment and residential buildings to underground and suburban train stations: 95% less than 500 m; 75% less than 300 m.
  - Density guarantees economic viability and efficiency of public transport.
  - Proportions and orientation of clusters.
- Energy efficiency of buildings
  - Objective: To look for the minimum energy (both in-body and from use) that can be achieved by a building with existing technologies (or that could be available in the next 5 years) with economic return.
  - Methodology: Four different aspects are analyzed: Geometry; Technical solutions (Facades, Windows, Insulation and Roof); Thermal, lighting and hot water installations (Design, Intelligent control system); and Use of new technologies (Low enthalpy geothermal energy, Solar for air conditioning and Glass: light sensitive designs and new types). It has been studied the economic return for each technical solution and it has been used several energy simulation models: ENERGY PLUS, TRNSYS, FLUENT, DOE2. A or B classification of the building should be attained.

Lessons Learnt

Proposals for the future:

Necessity of a minimum urban density for the viability of public transport

- Bus: 25 dwellings/ha
- Light-rail: 60 dwellings/ha
- Heavy underground: 100 dwellings/ha

In-body energy should be included in the energy certificate classification

- In-body energy accounts for 10 to 20 years of the annual energy used
- Producers of construction materials must provide an officially approved certificate for the in-body energy
- With the selection of construction materials, in-body energy and emissions can vary ±25%

Bioclimatic architecture needs to be analyzed analytically with simulation models

- It seems it can provide considerable energy savings but this needs to be quantified for each technical solution

New technologies and changes in legislation

- Integral design and energy management system of the building
- Development of low enthalpy geothermal energy
- Stronger prescriptions in the energy document of the building code
- Introduction of energy efficiency certificate for existing buildings
- Financial aids for buildings classified A or B in the energy certificate

City case study: Madrid

General data

Madrid is the capital of Spain, of the Madrid Community and the province. It is the biggest city and populated of the country, reaching officially 3,232,463 inhabitants (2007) inside with his city and 6,043,031 in its metropolitan area (2005), being by it the third urban area more populated in the European Union. The metropolitan surface is around 1,739,44 km^2 and the urban area 607 km^2.

The city of Madrid is in the central zone of the Iberian Peninsula. The coordinates of the city are 40° 28' N 3° 41' W and its medium altitude on the level of the sea is 595 m. The geographic and climatic context of Madrid is the one of the South Subplateau, within the Central Plateau. The city is located to few kilometres of the Mountain range of Guadarrama and it is located in the Tajo river basin. The climate of Madrid is continental Mediterranean Climate and very is influenced by the urban conditions.

The gross population density is around 1,700 inhabitants / km^2 and the gross employment density around 739.8 workers per km^2.

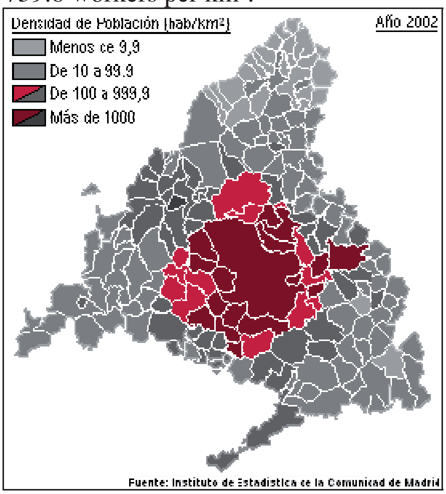

Figure XVII.vi - Population density in Madrid (inhab/km^2)

Transport

At the moment the Spanish public transport is one of the best ones of Europe, as much by its relation between quality and price and by its degree of integration. The key of the success has been the creation of the “metropolitan partnerships of transport” (public and deprived structure of proprietors).

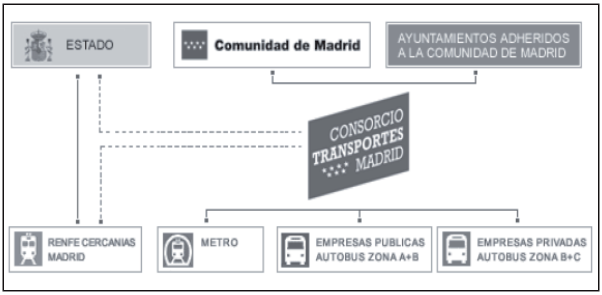

Figure XVII.vii - “Consorcio de Transportes de Madrid”

The Madrid transport system is integrated totally under a scheme of public and deprived investment that consists of the following services: urban subway (Metro), transport by urban buses (EMT), train (RENFE) and buses interurban.

The subway has happened to transport 523 million passengers in 2000 to 647 million in 2005 (23.7% of increase in five years). In the case of the metropolitan train also it was increased from 161.2 million passengers to 199 in such years (23 %).

The city council of Madrid has started up a green ring project for bicycles that will communicate all infrastructures for the 2012 year but the use of this means is restricted well by the geographic difficulties of the city. Because of this limitation, the motorcycle as means of alternative transport to the automobile, has increased its motor pool in the metropolitan area of Madrid. Thus, the motorcycles have been included like authorized vehicles to circulate around tracks reserved for buses and taxis obtaining a maximum yield for the track.

It has been calculated 474 cars per 1,000 inhabitants in the city of Madrid. The percentages of the total journeys carried out by public, private and non motorized transport modes are shown in the next table.

Modal Split	
Autobus EMT	22.80%
Metro	30.10%
Cercanias Renfe	0.60%
Car	33.70%
Motorbicycle	1%
Bicycle	0.10%
Taxi	9.10%

Table XVII.v - Modal split in Madrid city

The total length of segregated routes occupied by bus, light metro, conventional metro and rail lines divided by the total surface of the urban area is 1.3 km / km^2. And the energy used in transport per capita is around 5.700kWh / inhabitant x year.

Building

The dwellings in Madrid per 1,000 inhabitants have been calculated as 470 with an average age of the total stock of 37.84 years. The average number of floors above ground in the whole city is around 3.78.

The residential floor space per capita is 20.00 m^2 / inhabitant and the urban area per capita is 5.5 x 10^{-4} km^2 / inhabitant. The energy used in buildings per capita is around 8.400kWh / inhabitant x year.

All these indicators have been calculated based on the general statistics data of the National institute of Stastics (INE) and the municipality of Madrid (Munimadrid) for the 2004 year.

National conclusions

The challenges that appear in the case of Spain are by a side the reduction of CO_2 emissions decided in the Protocol of Kyoto (+ 15% with respect to 1990) for which is fundamental the reduction or stabilization of energy consumption and by another one the necessity to avoid the excessive outer power (and fossil fuel) dependency.

The fixed lines to be able to reach the noticeable challenges are: the saving and energy efficiency (E4), the use of the flexibility mechanisms established by Kyoto (carbon market) as well as the increase of percentage of renewable energies (PER) until 12 %. In the Spanish case, the renewable energies have a great potential due to the situation and climatology of the country. The solar radiation is very important (thermal solar and photovoltaic energy) as well as the wind power energy has a great importance.

In the presented case studies it is showed that the construction sector in an urban and building scale are very important from a carbon dioxide emissions and energy consumption point of view. It has been made a carbon analysis attending the importance of the emissions in the life cycle, the embodied energy during the construction phase and the energy consumption during the use phase. The selected city-planning plan as case of urban study, is an example of the sustainable objectives and responsible energy consumption that is being considered in Spain with aspects like bioclimatic houses, the use of geothermal energy, criteria of sustainable mobility or buildings classified only A or B.

The implantation of the EPBD which foments the power saving during the exploitation phase of the buildings (limitation of the power demand, HE-1) with the use of renewable energies united with the energy certification and the RITE, it is possible arrive at reductions between the 30-40 % of the energy consumption of the buildings.

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XVIII Switzerland

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National context

Switzerland is a small country (41,300 km^2), bordered by France, Germany, Italy, Austria and Liechtenstein. It is mainly mountainous (Alps and Jura) with a central plateau of hills, plains and lakes - the largest of which is Lake Geneva. It is the second most densely forested country in Europe. One quarter of the land is unproductive and, with the exception of water (and hydroelectric production), there are few natural resources.

Switzerland has a strong urban character (more than 75% of the population lives and works in cities or towns) and it is densely populated (average of 180 inhabitants per km^2). The phenomena of urban sprawl and functional segregation of space generates a large increase in mobility, particularly individual.

Climate

The Alpine chain acts as a major climatic barrier between the north and the south of Switzerland. Indeed, the south of the country is notable for the predominant influence of the Mediterranean, which is responsible for much milder winters than in the north. Apart from their role as a climatic frontier between the north and the south of the country, the Alps are also home to a multitude of complex micro climates.

By virtue of the alpine character of the country, climate changes have been particularly notable in Switzerland: in fact, the average temperature has risen by 1.5°C between 1970 and 2005, which is 1.5 times faster than that of other emerged lands in the northern hemisphere[6]. The retreat of the glaciers and the thaw of permafrost lead to ground destabilizing, reduction in the snow cover of medium height mountains and changes in the vegetation. According to climatic simulations, this tendency has environmental (30 to 50% of indigenous fauna and flora is threatened), economical (infrastructures, tourism, energy) and social (healthcare costs) consequences.

Demographics

The Swiss population has more than doubled since the start of the 20th century: from 3.3 million (in 1900) to 7.6 million (in 2007). The different regions benefited unequally from this population growth: population increased mainly in urban areas and outlying communes, to the detriment of rural regions. Switzerland has one of the highest proportions of foreigners in Europe, sometimes coming from distant countries.

Carbon dioxide emissions

In 2004, the Swiss CO_2 emissions per inhabitant amounted to 6 tonnes (7.2 tonnes of CO_2 equivalents) according to national records. However, taking into consideration embodied emissions in sales of goods and electricity, emissions increase to 10.7 tonnes of CO_2 per inhabitant (12.5 tonnes of CO_2 equivalents). Switzerland thus transfers a large amount of emissions abroad. In comparison to the rest of Europe, Switzerland imports by far the highest proportion of CO_2, i.e. 63%, in relation to direct emissions[7].

Between 1950 and 2005, the proportion of CO_2 increased from 54% to 85% (80% due to the consumption of fossil fuels and 5% coming from the production of cement, trash incineration, and chemical processes), while the proportions of methane and nitrous oxide have decreased overall from 46 to 13%.

Approximately 35 % of CO_2 emissions in Switzerland come from transport (excl. international air traffic); home heating systems account for 25%, and industrial processes contribute 20%[8].

6 Consulting organization on climate change (OcCC)", Report on Climate Change and Switzerland in 2050", Bern, 2007.

7 Federal Office for the Environment (FOEN), "Graue treibhausgas-Emissionen der Schweiz 1990-2004", Berne, 2008

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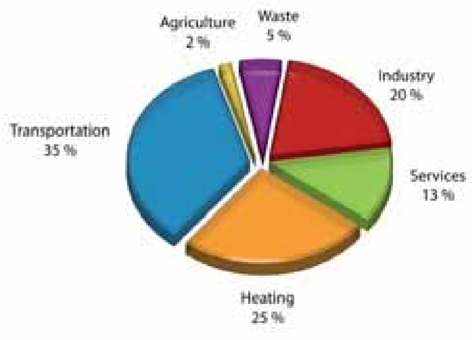

Figure XVIII.i – Sources of CO_2 emissions (FOEN, 2007)

Energy in Switzerland

Switzerland only has small reserves of raw materials; for this reason 80% of its energy requirements are met by import. Moreover, the majority of the energy consumed comes from fossil fuels.

In 2006, the final energy consumption was split as follows: 31% from fuel oils, 24% from combustible fuels, 23% from electricity and 12% from gas. The proportion of the renewable energy sources was 16.2%[9] (hydropower, solar and wind mainly) of the final energy consumption.

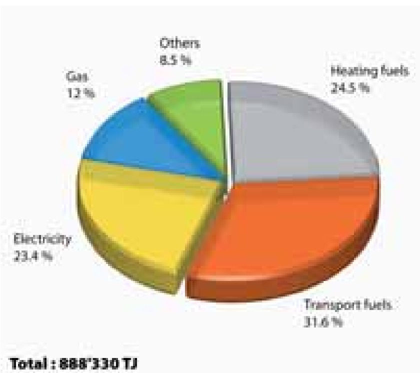

Figure XVIII.ii –Final energy consumption by energetic agent (OFEV/OFS, 2007)

The electricity production in Switzerland is virtually without CO_2 emissions due to the importance of hydropower and nuclear energy.

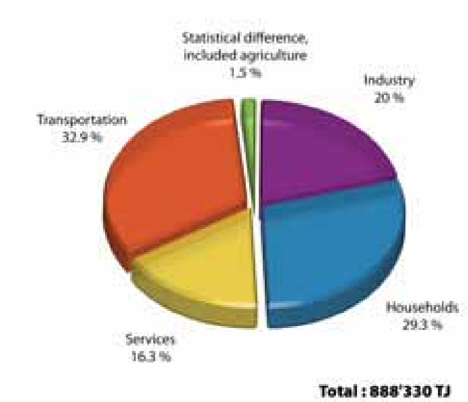

Figure XVIII.iii – Final energy consumption (OFEV/OFS, 2007)

It is estimated that by 2020, the country's needs for electricity will no longer be met by domestic electricity production and the existing import contracts.

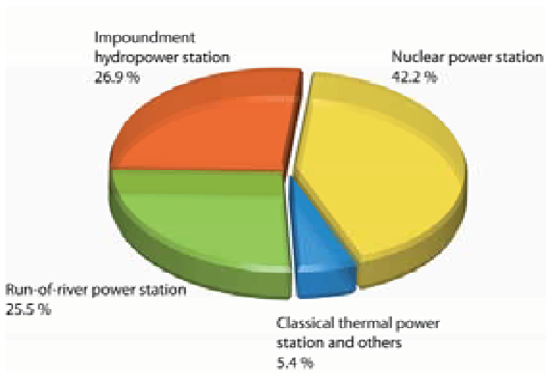

Figure XVIII.iv – Electricity production (OFEV/OFS, 2007)

Building regulations

From the constitutional point of view, energy policy in the construction sector is primarily the responsibility of the cantons (art. 89 al.4).

As Switzerland is not a member of the European Union, it is not required to implement the EPBD directive. However, as a member of the European Committee of Standardization, Switzerland is compelled to adopt the standard methodology of calculation used by the European Committee of Standardization. The Swiss Society of Engineers and Architects (SIA) is thus preparing several new standards, while the formulation of an equivalent law in Switzerland remains an open question. Without legal foundations, there will however not be any obligation to implement the above-mentioned standards in Switzerland.

9 "Environnement Suisse" 2007, OFEV/OFS, Berne, 2007.

EPBD implementation

Calculation method

The European Union has introduced in the EPBD the possibility of legal constraints on the basis of various indicators[10]; an explicit reference is made to the prEN 13790 standard, which corresponds to the Swiss SIA 380/1 Standard "Thermal energy in buildings". This standard is a method of calculation of energy needs and includes the definition of target values concerning energy consumption (per square meter and per year).

Energy performance requirements

Most of the cantons base their regulations on the SIA 380/1 standard. However, more than half of the cantons have implemented stricter energy prescriptions. Since 2001, energy efficiency programmes in the buildings sector (MukEn modules, model cantonal energy provisions) are produced by the cantonal energy departments which set out general principles related to buildings. For owners, the MukEn modules mean that maximum values of regulations for new buildings or for renovations are determined.

The two major modules of the MukEn are included in most cantonal legislations: in this way, basic module 1 defines the limited value according to the SIA 380/1 standard as a legal prescription for new buildings; basic module 2 "Maximum percentage of non-renewable energy" (80/20 rule)[11] ensures that the needs in terms of renewable energy are covered. Besides that, it is strongly advised that other modules be instituted as well.

The Federal Counsel supports the revision of MukEn in order to reduce, through homogeneous standards for the whole country, not only the total consumption of energy for newly-constructed and renovated buildings, but also the percentage of fossil energy. According to the revision (April 2008), the maximum demand for thermal energy for new buildings is reduced by about one half, which results in a use of 4.8 litres of heating oil per square meter of habitable space (and no longer 9 litres). This reduction corresponds approximately to the limit value for constructions that bear the MINERGIE label (see below). However, the label is not compulsory and the decision on how to achieve this objective (4.8 litres of heating oil per square meter) is left up to building owners (different methods are possible according to the specific requirements of each building). The cantons are responsible for putting these recommendations in place in the course of the next 5 years.

Energy performance certificates

Within the framework of revising MukEn, the cantons are examining the usefulness of a Cantonal Energy Performance Certificate for Buildings established on a Swiss scale. The goal of this certificate is to inform about the consumption of energy in each building; it will be introduced during the 2009-2011 period, the Federal Counsel recommending its adoption on a legal level. The introduction of this tool within a MukEn module will allow the cantons to suggest renovation measures to property owners or to centre their promotional policies on such measures.

For buildings constructed before 1995, the Federal Counsel plans to institute a national program to promote the energy renovation of buildings ("Refurbishment Program 2010-2020")[12] ; according to this program, an incentive will be put in place to modernize the buildings in order to conform their energy consumption levels to the MINERGIE standards.

The MINERGIE standard is a quality label which certifies new or renovated buildings that have a very low energy consumption (about 40% to 60% less than a traditional building). A MINERGIE building is identified by three principles based on the following: airtight envelope provided with excellent thermal insulation; gentle and automatic ventilation; production of adapted and efficient heating (preferably renewable energy). The MINERGIE-P standard presents requirements that are more stringent than the MINERGIE standard: the insulation is thicker, the envelope is more airtight, and the requirements for heating are higher; renewable energy is mandatory, and electric appliances must use even less energy. MINERGIE-ECO standard complements the MINERGIE or MINERGIE-P standards. The buildings constructed according to MINERGIE-ECO must satisfy additional requirements for healthy construction (daylight, noise, pollutants) and ecological concerns (materials, demolition, flexibility, limited damage to the environment, etc.).

10 The evaluation of buildings must be carried out with indicators calculated on the basis of standard energy use. Possible indicators include: primary energy, the final energy (weighted), CO2 emissions, and energy costs.

11 Non-renewable energy in new buildings must not exceed more than 80% of heating needs (heating and hot water).

12 Which will replace the refurbishment program of the Climate Cent Foundation, since it ends in 2009 (see below).

Even though, the heated floor surface (wall included) for certified buildings (Minergie and Minergie-P) has continually increased for the last ten years, this surface totalled only 0.9 % of the total heated floor surface in Switzerland (2006). At the end of 2008, the country counted about 9,000 MINERGIE buildings, amongst which 1,000 are renovations. All the cantons encourage directly or indirectly the enforcement of the MINERGIE standard.

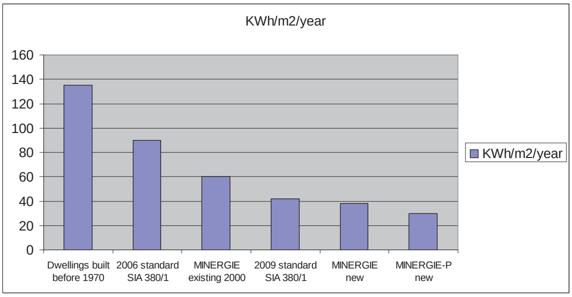

Figure XVIII.v – Construction and energy standards (FOEN, 2006)

To conclude, it is clear that Switzerland – which is largely a country of renters – finds itself faced with the following paradox: for existing buildings, the costs of insulation and heating improvements are paid by owners, which means that the owners receive no return on their investment; they are thus hesitant to undertake refurbishment measures, since only the renters will profit from reduced energy bills. To mitigate this problem, alternative solutions are currently being investigated, such as including the refurbishment costs on rent, implementing tax-breaks or deductions, and/or grants to owners. The situation is different for new buildings: the owners are required to abide by the standards and grant systems have already been instituted; finally, the fact that a building is energy-efficient is not a negligible sales argument.

Planning legislation

Switzerland has recently set out goals comparable to those of the European Union, including a reduction in the emission of greenhouse gases by at least 20% between now and 2020, and by 50% between now and 2050 (using 1990 as a reference year).

The basic rules of environmental protection are outlined in the new Federal Constitution (1999), particularly through the following principles: precautionary and polluter pays (art. 74), sustainable development and preservation of natural resources (art. 2).

The Federal Law on Land Management (LAT) (1979) contributes indirectly to the reduction of CO_2 emissions by setting out principles of land management, such as a moderate use of the land, densification, control of urban spread, and development which is primarily based on the best-served areas.

The Federal Act on the reduction of CO_2 emissions (called CO_2 Act) (2000) – coherent with the Kyoto protocol - sets out the following objectives for the reduction of CO_2 emissions originating from energy consumption: a reduction by 10% of global CO_2 emissions between now and 2010, in comparison to 1990; a reduction by 15% of CO_2 emissions due to combustible fuels, and a reduction by 8% of CO_2 emissions due to vehicle fuels. In addition, this Act aims at "reducing other damage to the environment, to achieve a rational and economic use of energy, as well as to increase the use of renewable energy" (art. 1). The CO_2 Act stipulates that if the reduction objectives are not achieved through voluntary measures, a tax on CO_2 should be introduced. In this context, the Confederation has recently (beginning of 2008) modified the Ordinance on CO_2 tax by adding parameters for implementing a progressive incentive tax on combustible fuels (home heating oil, gas)[13], depending on the results obtained. For vehicle fuels (petrol, diesel) – the introduction of a tax having widely been contested by automobile lobbies – the Federal Counsel has agreed to institute the Climate Cent (2005). Through this measure, the Swiss Oil Association – supported by other business and transport associations - is setting aside a sum of 1.5 cents per litre of petrol, the revenue being assigned to Swiss and foreign projects. The CO_2 Act, which expires in 2012, is currently revised in order to conform to the post-Kyoto climate policies, the revision being based notably on an incentive climate tax, technical regulations (for buildings and vehicles) and the financement of regulatory measures.

The Energy Law's goal (LEne) (1999) is to favour a safe energy supply, to contribute to an economical and rational use of energy, and to encourage the use of local renewable energy. The law envisions that, between now and 2030, the production of electricity from non-renewable sources will increase considerably (+5400 GWh), and that the total consumption of energy by households will stabilize at the current level. This law is under revision ; the modifications relate to the creation of a Certification of Energy Performance for

13 It is planned that these amounts will be redistributed to the population through health insurance and to the economy sector through compensation funds.

buildings on a national scale, the withdrawal of household and electronical appliances consuming too much electricity (in use and in standby) and the increase of cantonal subsidies for promotional and information programs of renewable energy.

The Swiss Energy Program – which is based on the different laws mentioned above – was conceived as an integral part of Swiss policy concerning climate and energy. This program serves as an interface between voluntary action and legal obligation; it works towards energy efficiency and the use of renewable energy, and directs its action towards a 2000-Watts society [14]. Within the framework of this program, measures are developed in various areas such as urban and regional planning, transportation, buildings, household appliances, etc.

At the beginning of 2008, the Federal Counsel has adopted an Action Plan for Energy Efficiency and an Action Plan for Renewable Energy, stating that the consumption of energy could be reduced by 30 to 70% depending on the sectors during the next twenty years, thanks to the implementation of the best technologies available ("best practice"). This corresponds to a reduction in fossil energy consumption by 20% (1.5% per year) up to 2020 and a maximum increase of electricity consumption by 5% between 2010 and 2020.

The Action Plan for Energy Efficiency comprises fifteen measures, based on the Energy Perspectives and their scenarios developed by the FOEN [15] ; these combine incentives, instructions of use, minimum standards, promotional actions, and measures in the sectors of research, education and building regulations[16]. Regarding transportation, it is anticipated that the new convention of objectives with Auto-Swiss will be stricter (the objective of 2002 not having been reached). In addition, a penalty/bonus system is under discussion [17]. Finally, a cantonal system of taxing automobiles according to their fuel consumption will soon be implemented. Certain cantons – including Geneva – have already adopted this measure.

14 The 2000 Watts society vision emphasizes that a person needs 17,500 kilowatt-hours a year on global average. This corresponds to a continuous requirement of 2000 watts, with only 500 watts being produced from fossil fuel sources. In Switzerland, the figure is currently three times higher, i.e. 6000 watts per person.

15 Federal Office for the Environment (FOEN), Energy Perspectives for 2035 (1rst volume) – Synthesis, Bern, 2007.

16 For more details about these measures, we refer the reader to the section « EPBD »

17 This measure could be put into action in 2010.

The Action Plan on Renewable Energy brings together seven measures. These are focused above all on heat production (home heating and hot water) - where there is the most potential to substitute fossil fuels with renewable energy - but also on hydraulic energy and vehicle bio-fuels. The goal of this action plan is to increase the percentage of renewable energy in overall energy consumption by at least 50% between now and 2020 (from 16.2% today to 24%).

Finally, certain peculiarities of the Swiss legal system concerning road transport should be noted : these comprise in particular the royalty on the traffic of heavy trucks linked to the performances (RPLP), which involves a fee to be charged on heavy trucks which weigh more than 3.5 tonnes (according to the number of kilometres travelled on Swiss territory, the total weight allowed, and the pollutant emissions of the vehicle).

Regarding new cars destined for private use, they have to be systematically outfitted (since 2003) with an Energy Label [18] which allows for classification according to categories of energy efficiency and the presence or absence of a particle filter for diesel vehicles. The Federal Ordinance on Energy plans to periodically adapt the Energy Label according to the evolution of the situation. The revision (July 2008) allows for the reinforcement of allocation criteria to an increased efficiency category. The next significant step should take place in 2010, with the introduction of an Environment Label that will replace the Energy Label. The Environment Label will allow for differentiation between vehicles according to criteria, which include not only efficiency, but also ecology (atmospheric pollutants, noise disturbance, climate effects, etc.); these indications will determine the cantonal taxes on motor vehicles or the federal taxes on imports.

In conclusion, Switzerland will have to face considerable challenges in the coming years: climate change, safety of supply, exhaustion of fossil fuel reserves, impending end of Swiss nuclear production, expiration of long-term contract for the importation of electricity, shortage of electricity, etc. In view of these challenges and of the growth in energy consumption, it is evident that the measures which have been implemented until now are insufficient, and that new legal foundations should be put in place as soon as possible.

18 Ordinance 730.010.1 and following

The city of Zurich

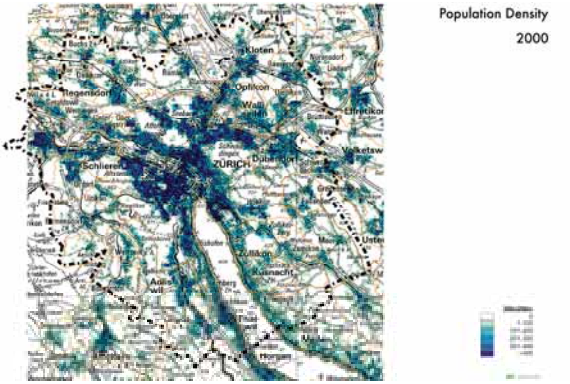

Figure XVIII.vi - Population Density in the city of Zurich and the first expansion rings

Zurich, located in the northeast of Switzerland, is the biggest city of the country and is a European pole of financial and commercial interest. The city of Zurich (380,499 inhabitants - 2008) is growing over its political borders since the end of the 19th century, becoming the centre of a conurbation with over 1 million people. Considering a metropolitan area that includes the first 2 expansion rings (see the map) a resident population of 678,975 is living in an area of 366 km^2 (gross density 1,855 inhabitant/km^2). In the same area, there are 525,635 working places (3 working places every 4 inhabitants), the commuting is therefore rather high. The GDP was in 2000 about €64,000 /inhabitant.

Traffic Policy

The current Zurich's traffic policy is based on the choices done in the seventies. In 1962 and 1973, two projects for the construction of an underground in Zurich were rejected by popular vote. This vote against great investments in new technologies made clear that "tax-payers" wanted the existing public transport system working better and more efficiently instead of new projects with uncertain results. On this base the municipality of Zurich worked out a new transportation policy based on three principles:

- Limitation of the number of private vehicles entering downtown.
- Guiding car traffic on the principal axes, speed and access limitation on secondary roads.
- Improvement and encouragement of the public transport and pedestrian mobility.

Investments in the improvement of the existing tram and bus network were done and, at the end of the seventies, clear instructions were given to all the public offices of the city in order to "give way to public transport, pedestrian, bicycles, handicapped people, etc" and to "take care of the environment, life quality in the residential areas and of the urban aesthetics in all planning and management activities". The Transport Strategy Act of 1987 was even more explicit as indicated the following priorities:

- Improvement of the public transport.
- Reduction of private traffic.
- Private traffic removal from the residential areas
- Reduction of parking places for commuters and no new parking places in town.
- Encouragement of pedestrians and bikers.

Moreover it was decided that all the areas with 300 or more inhabitants or working places have to be well connected to the public transport network (a bus stop within 300 m or a train station within 750 m, with at last one connection every hour between 6am and midnight).

Also as result of these policy, Zurich is one of the city with the higher modal split on public transport (about 40% of the trip) and with the lower number of cars per capita (about 0.35 in the city, about 0.5 in the first 2 development rings).

Road to the 2000 Watt society

The city of Zurich is traditionally engaged in the improvement of the environmental quality of the city. The engagement has been formalized in law with the popular vote of November 2008; a large majority of dweller decided to fix an energy consumption goal of 2000 Watt/inhabitant (which is the actual worldwide mean consumption). Currently, each resident consumes energy at an average rate of 6,000 Watts. This is to be cut to 2,000 by the year 2050. Within the same time frame, carbon dioxide emissions would be cut from six tonnes per person to one tonne, by sourcing three quarters of the city's energy from renewable supplies.

Case study 1: The regional railway lines network of Zurich (S-Bahn)

Facts

- Inauguration: 1990 as first suburban train network in Switzerland.
- Extension of the network: 230 km.
- Number of carriages: 1,202 carriages (2005).
- Number of lines: 13 radial lines departing at the Zurich Main station.

- Type of Timetable: regular pace (based on a 30-minute frequency, 5:30 – 24:00).
- Average passengers pro workday: 320,000 (passengers that travelled over the city borders, all corridors, all directions).

Aim

To fulfill the increasing requirements of the population and of the economy, the historical dense but relatively “slow” tram network, has been optimized and completed with a new “fast” suburban train network. The former should collect and distribute whereas the latter is in charge for the transport across distances longer than 5 km.

The “new” S-Bahn network has been largely based on existing infrastructures. The core of the realization of the future 320 km high value network has been a new 12 km long (or “short”) highly strategic connection across the town (the missing piece), a new passing railway station (underground, under the main station), as well as many small improvements on existing lines and stations.

Decision Making

The creation of the new suburban train network had big impact on the city of Zurich and on the habits of its dwellers. The accessibility from outside the town resulted greatly improved and the success of the new offer can be easily read from the frequency data of the first 15 years of service (1990 – 2005).

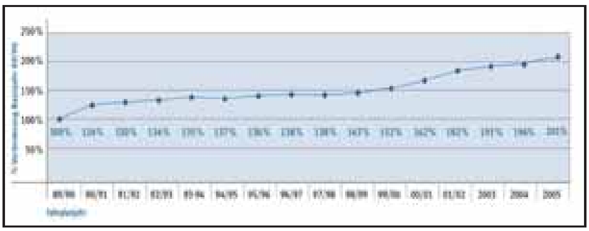

Figure XVIII.vii - Development of the travellers on the S-Bahn Zurich (passengers that travelled over the city borders, all corridors, all directions per working day)

The development of the travelers, reported in the figure, shows that the users of the S-Bahn doubled in 15 years, from about 160,000 in the 1990 to about 320,000 in 2005. Nevertheless the developments program never stops, and little improvement, as well as big new investments (i.e. the new second train city link north-south that will added to the first east-west train link). Projections indicate the possibility of reaching 550,000 travelers per working day in 2025).

Founding

The original founding for the achievement of the infrastructure has been granted (1/3 each) from the City of Zurich, the Canton of Zurich, and the SBB (Swiss National Railways).

In 1990, contemporary to the beginning of the S-Bahn service, has been established the ZVV (Zürcher Verkehr Verbund) which is in charge of managing the founding of the public transport in canton Zurich (train, tram, bus, ferry). Thanks to the ZVV, that acts as interface between travelers and carries, the users can benefit from a total ticket integration across the whole public transport offer of the canton.

The founding mechanism is based on a mixed scheme, by which the transport is partly financed directly through the ticket (about 55.5% in year 2005), and partly through the Taxes (about 44.5% in year 2005). The distribution of the costs among the different towns is made according to the number of departures (i.e. quality of the service, 80%) and to the amount of tax incomes (i.e. richness of the town, 20%). In 2005 the total costs of the ZVV have been about 700 Mio. Swiss Francs (S-Bahn, Tram, Bus, etc.).

ZVV is responsible of the distribution of the collected money among the 41 transport carriers that are active in the canton, according to the offered kilometers and to the negotiated fee.

Assessment

As already noted the success of the S-Bahn Zurich is undisputable. The number of passengers showed an increasing trend from the beginning of the service that led to doubling of the initial amount of passengers/day in 15 years. Nevertheless on a low carbon perspective the problem is more complex and additional parameters need to be considered.

Near the increasing of the passengers on the trains, no notable decrease of the car traffic has been recorded; this seems to indicate that the majority of the new S-Bahn travelers are “new” travelers that exist because of the S-Bahn. Thus the modal change effect (people that decided to leave the car to use the train) has been only marginal, and no reduction of the global CO_2 emission could be observed.

The developing of the S-Bahn network increased dramatically the radial accessibility to the city of Zurich along its corridor; this influenced the urban and land planning as well as distribution of the population.

This scheme could push up the length of the travels to the working places; moreover the decentralization of the population along the regional train lines can easily produce "collateral" car travels: the inhabitants of the small centres can on one side benefit of a very good radial public transport service toward the big city centre, but on the other side the quality of the local offer cannot reach the same standards, the result is that they use the public transport to reach the city (mainly to reach the working place, this kind of travels are about 30% of the total), but tend to use the car for all the other movements. The resulting advantage in terms of CO_2 may be at the end not so clear.

It is difficult to say what would has been the development without the new suburban network, the existing road network as well as the parking places in the city, hadn't have the capacity to support the same growth of passengers that has been observed on the S-Bahn from the 1990. For sure the relocation of the growth registered on the train to the road would have been, from the CO_2 perspective definitively worst and practically unsustainable. From this perspective is possible to conclude that the new S-Bahn system definitively represented by far the most sustainable and effective way to support the expected economical growth of the city of Zurich.

At the end still an open question: Would the metropolitan area of Zurich have grown even without S-Bahn in the some way? And what would have been the mobility characteristics of the people not joining the Zurich area?

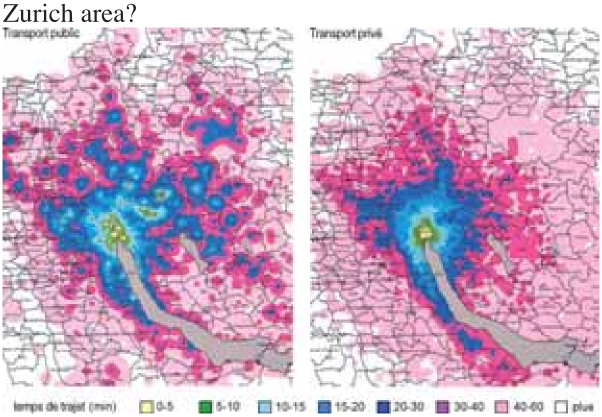

Figure XVIII.viii - The travel time to the city center of Zurich, public transport and the S-Bahn in particular built a "bubble" scheme in which the linearity between distance and travel time is not respected

Case study 2: New strategies for the reduction of shopping centres generated car trips – theory and experiences in Zurich.

Shopping and Traffic Policies

Shops need to be accessible to costumers. From the beginning of commerce's history, a good (accessible, visible, etc.) position has been regarded as one of the key factors to the success. From the time of the ancient Rome to the middle age, and later on during the Renaissance, commercial facilities used to have reserved spaces in high quality urban space (the forum near the senate in Rome, the market place, oft near the Town Council in middle age cities, the commercial streets in many modern cities).

At the same time several factors, among the others the relationships between life and commerce, local citizens and (foreign) merchants, political authority and economical power, as well as accessibility problems and requirement of space, made the positioning of trading facilities a more complex problem without any obvious solution.

In ancient Rome the market was at first located near the senate, but with the increasing commercial activities, the senators decided to "relocate" it because of the disturbing noises. During the early Renaissance Florence founded several new towns providing trading spaces on the main square; in few years they decided to move the weekly markets outside the town walls (in the "mercadale"), and in the later projects the main place has been directly reserved only to government functions.

The rural and scattered character of the middle age Britain (together with the suspects that the nobles and the Church always reserved to the economical power of stranger goods and money dealers) gave the impulse to the development of a network of "market towns", segregated from the "normal" villages, but at the same time characterized by a high level of accessibility. These towns consisted usually of just a single street with a wider central part (the square), surrounded by two lines of houses (shops as well as merchants' residences).

Figure XVIII.ix - Chipping Campden (England) founded in the Middle Age as Market Town

The “friends’n’enemies” relationship between urban spaces and shopping facilities continues in the modern cities. Shops are at first concentrated in high value rather central commercial zones and streets. Then, their increased need of space, and above all the chimera of total accessibility by private cars, led to the idea of bringing car traffic and the related parking problems away from the small, not car oriented, cities centers, and to the development of the big, decentralized and car accessible, shopping malls.

At the beginning of the shopping malls era, the biggest perceived problem was the availability of enough parking lots. Technical norms and guidelines of the 70s and 80s provided indications to the definition of the minimum amount of parking places that have to be provided in connection with the construction of a new commercial centre. Later on was also clear that it was not sufficient to provide cars with the place to stay, indeed it was needed to dispense them also the place to arrive and to go away. Updated guidelines gave indications about the dimensioning of the junctions and of the connection to the streets network.

Nevertheless the constant increase of car traffic in cities, together with all the related problems of congestion and pollution, clearly shows that trying to follow the demand with the expansion of the offer cannot be regarded as the definitive solution.

Shopping and Facts

Traffic policies are often based on prejudices and superstitions; among the others it is impossible to make shopping without a car because of the bags, customers that use public transports use to buy less than the motorized ones.

A research project of the RZU (Regional Planning of Zurich and its Area) investigated in year 2001 the habits of the customers of four commercial zones in the area of Zurich. All the zones are located in suburban and non-residential districts. Within the inquired districts are to be found 2 shopping malls, 9 furniture shops, 3 hobby markets, 4 Electronics shops; the total shopping surface is about 175,000 m^2 and offers 10,000 parking places.

Interviews and measurements have been made on Saturday, that is normally the more important shopping day, and on Tuesday, as average working day. All the facilities are closed on Sunday. It is interesting to note that although 60% more customers have been observed on Saturday, the number of counted cars resulted on Saturday just 25% higher. The difference has to be found in the number of passengers per car, which is on Saturday 1.83 instead of 1.40.

All the considered commercial zones are reachable with the public transport, nevertheless the quality of the services shows notable differences:

- Wallisellen Glatt, 3 lines - 10 couples of buses/h,
- Dietlikon Industrie, 2 lines – 3 to 4 couples of buses/h,
- Dübendorf Hochbord, 2 lines – 6 couples of buses/h,
- Volketswil Industrie, 2 lines – 2 to 4 couples of buses/h.

None of them is directly connected with the high value public transport network of trams and Railway. The research shows (or confirms), that the use of private car is by far dominant, and varies from 83 to 97%. The use of public transport is more or less proportional to the quality of the provided service, and just in the case of Wallisellen Glatt is higher than 10%. As a reference, the modal split of the citizens of Zurich (for “in town” shopping) is about 6% on car, furthermore about 18% of the customers (including non residents) of the Bahnhofstrasse shops (the main commercial streets in the city centre of Zurich), uses a car to make shopping.
More interesting is the volume of the goods that the average customer uses to buy. According to the research almost 60% of the shoppers leaves the commercial zone with nothing more than a bag, near ¾ of them doesn’t have to carry around more than 2 bags, while 30% of the visitors needs to transport more than 2 bags. According to these numbers about 60% of the commercial zones customers could carry on their shopping activities without the help of a car, at least for the transportation of the goods.

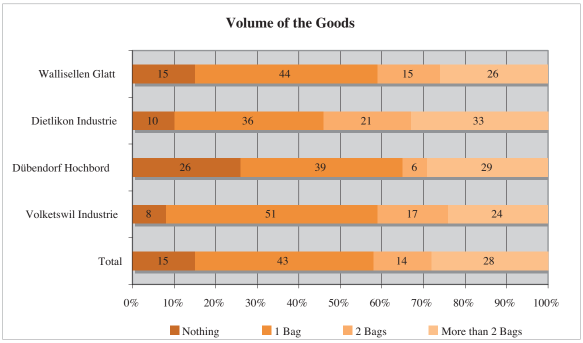

Figure XVIII.x - Volume of goods that the customers use to buy during a typical shopping session

Within the same study have been investigated the value of the bought wares. The results show that there is not any big difference between cars and public transport users, in particular the second ones, in average, use to spend even more than the motorized ones. Or in other words the motorized ones have a much higher level of "buying nothing cases" than the public transport users.

Pedestrians and cyclists use to buy less by single shopping trip, but they use to make a higher number of trips, that make them interesting clients anyway.

Parking policies in Switzerland

The traditional traffic and town planning norms in Switzerland provide indications about the number of parking lots to be provided in connection with the construction of new buildings. The minimum is intended to avoid the impact of parked cars (and of the "looking for parking" traffic) on the surroundings, whereas the maximum is meant to control the induced traffic.

The number of park places are computed with reference to the planned functions (residential, services, shopping), and corrected according to the quality of the public transport offer.

At the end the additional traffic generated by the new structure is assessed, and the environmental (pollution, noise) and junction loads compatibility are proofed.

The result of this process is a certain number of "specialized" parking lots, which should generate an acceptable volume of traffic and not more. Each parking lot can be used only for the original function (in case of multifunctional structures the shared used of parking lots is not admitted: i.e. shopping customers lots cannot be used on Sunday by football fans).

An Innovative Approach: "Zurich's Trips Model"

The ruling of the amount of parking lots is an indirect way of controlling traffic loads and therefore noise and pollution. However parked cars produce neither noise nor pollution. The trip model moves the focus to the factors that are directly responsible of the disturbing emissions, namely the amount of car trips. In connection of a new building license a certain amount of car trips, which should be compatible with the characteristics of the existing surrounding streets, junctions, noise and pollution in the residential areas, etc., has to be decided. This amount will be the threshold that has to be respected during the functioning of the structure. How this result will achieved (for example with the enforcing of parking policies) is not directly ruled and it is not part of this kind of regulation.

The biggest difference between the classical approach and the new trips model is that the managing of the parking places is free, because the number of runs is the only considered parameter. This puts on one side the spots on the crucial themes allowing the explicit managing of the traffic flows, and on the other side provides the investors with a higher level of flexibility in parking lots design and management (no function based segregation, shared use of the same place for different uses, adjustments of the functions and of the surfaces, etc.). Moreover these kinds of models introduce, through the real-time monitoring of the generated traffic during the life of the structure, a dynamic component, whereas the classical approaches are totally static. In classical models the compatibility of the new structures is proofed just once during the design phase, adjustments during its life span are therefore not foreseen. On the contrary one of the principles of the new "dynamical" model is that the set requirements have to be fulfilled during the entire life of the structures, any diversion has to be corrected, with new policies, strategies as well as infrastructural adjustments.

The Actors

The trips model needs three actors to work together:

- The public administration. That issues the licence, sets the trip threshold and in case orders mandatory correcting measures.
- The investor, or the manager of the new structure, that sets up an internal organization to manage the

respect the thresholds.
- An independent authority, which has to proof the controlling methods and reports.

In addition a notable role in traffic management strategies is in Switzerland traditionally played by NGOs, that uses to independently check the new projects and to denounce misuses ad other problems.

The Set up

In the implementation process of a trip model the most important part is the definition of the trip budget (thresholds). This is computed using the same methodology of the “classic” model (see the paragraph "Parking policies in Switzerland”) according to 4 main parameters:

- The required number of parking places per m^2 of functional surface. The resulting number has to be adjusted according to the public transport quality of the zone.
- The assessing of the number of trips, calculated on the basis of: the parking lots number and the typical generating factors (according to the function).
- The sustainable number of trips taking into account streets and junctions capacity.
- The sustainable number of trips taking into account air pollution, noise, etc. (the environmental compatibility assessment is mandatory when the needed number of parking place is higher than 300. In these cases becomes usually crucial).

If necessary the assessed trips budget can be differentiated between day and night, moreover different budgets, corresponding to different realization phases of the main structure, or to the development of the public transport offer, as well as of the characteristics of the surroundings (residential density, work places, and so on) can be defined.

It may be interesting to note that the in comparison to the traditional approaches, the trips model may lead to the construction of a lower number of parking lots (this is especially true in case of structures with mixed functions) as well as higher (for example if peak hours flows wouldn’t be considered problematic). Once again the only determining factor is the number of generated trips. A good example of programmed step is the application of the trips model to the project of the new football stadium of Zurich.

Controlling and Management Strategies

The continuous monitoring of the car trips to and from the structure is an essential part of the model. To make it possible it is necessary that the area to be monitored is closed and isolated from other structures that are not subjected to the same trips model.

Because of the limitation of the trips, the structure’s management is forced to develop strategies to encourage the car free access. These can be for example the management of the parking places (parking rates, time limitations, dynamic management of the available number of parking lots), the integration with the public transport (information, waiting areas, public transport ticket rebates, etc.), as well as any other innovative measure to attract car less customers and visitors.

It may worth to note that in case of commercial facilities, it may worth to keep the customers as much time as possible inside the structure. This would indeed improve the spent money/trip ratio and then the economical efficiency of the structure. High quality spaces and a well-differentiated offer could be therefore determining factors for good economical results.

If the self issued management strategies wouldn’t succeed, and the trips budget happens to be systematically exceeded, the public administration is entitled to enforce “emergency” measures. These can be a monetary fine (proportional to the number of exceeding trips), the limitation of the parking lots according to the functions or the time, or the reduction (or the increase) of the parking places according to the traditional norms (in this case the shared use between different functions wouldn’t be allowed anymore). It is foreseen that the money that should be earned from the fines has to be used to improve the public transport in the surroundings.

The Sihlcity is the last newcomer within the now richer panorama of shopping centres in Zurich. It is located on the southwest edge of the city and is the result of the conversion project of a paper production plant. The Sihlcity has the ambition of opening a new generation of shopping centres that should mark the end of the conflicts between high quality urban spaces and large scale shopping facilities.

Really impressive are the numbers related to traffic and public transport integration. The multifunctional centre (near the shops are provided, Hotels, Spas, Libraries and even a multi-confessional chapel) is fully integrated in the high value public transport network of the city of Zurich. It is accessible through two tramlines, one bus line as well as a regional Train (S-Bahn), that provide about 30 pairs of runs during the peak hours (one every 2 minutes).

The imposing public transport accessibility allowed the enforcement of a rather restrictive trips model. About 20,000 visitors per day are expected (about 6.0 million/year) whereas only 8,800 car-trips/day (a single visit needs two trips, to come and to go) has been budgeted. This means that about 60% of the customers should reach the new shopping temple without the help of a car. As already seen in this paper this modal split target appears to be very ambitious if compared with the usual numbers (10 – 20%) of the large scale shopping facilities.

The Sihlcity has been inaugurated on 22nd March 2007 and within the first 100 days has been visited by an average of 19,000 visitors per day with the impressive modal split of 28% on car. No parking problem is therefore been registered, with some minor exceptions during the Saturday's peek hours. To help the non-motorized shopping an innovative and cheap service (about €3 to any address within the city of Zurich) of home delivery with electro bike or tram has been provided, it is partly endowed by the city itself. In the first phase of the project more than 2000 deliveries have been carried out, the service capacity will be enlarged in the future. The first results are to be considered really encouraging and show that it is possible to set up profitable commercial activities without focusing the accessibility on the use of private cars.

	Glattzentrum Zürich Nord (1975)	Sihlcity Zürich Sud (2007)
Surfaces of Shops, etc.	43'400 m^2	65'000 m^2
Nr. of Shops	96	80
Nr. of Restaurants	9	13
Nr. of Cinemas	0	10
Nr. of Employees	1'250	1'300
Nr. of Visitors/Year	6.1 Mio	6.0 Mio (estimated)
Nr. of Parking Lots	4'750	850
Nr. of Car trips/day	26'000 (13'000 + 13'000)	8'800 (4'400 + 4'400) trip limit
Modal Split Car	83%	40% est. 28% (1st 100 days)
Supply public transport	3 bus lines (mittle-low frequency)	2 tram lines (high freq.) 1 bus line 1Commuter train stop
Motorway supply	Direct	Near by

IBV

Figure XVIII.xi - Construction and energy standards (FOEN, 2006)

Case study 3: EMPA EAWAG building

The EMPA EAWAG building is designed with five floors of offices distributed in a U-shape around an atrium, with its suspended meeting boxes and open staircases encouraging the use of stairs rather than lifts. It provides office space for 150 employees, a lecture hall for 80-140 people, seminar and meeting rooms, a joint library and a staff canteen. It has a total floor area of about 8,500m. The building has no conventional heating or cooling system. Vertical blue glass panels act as external shading devices that move in response to the sun path and let daylight. The glazing system G value is between 0.1-0.4. The building is highly insulated and of a compact form with U value of walls and roofs less than 0.12 W/m^2k and windows of 0.5 W/m^2k. The clay and gypsum walls regulate the internal air humidity by absorption and desorption at the internal wall surface.

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The exposed concrete construction provides thermal storage. During summer nights when the external temperature drops below room temperature, the cooler outside air is drawn into the building through openable windows in the external façade and is then drawn through the internal spaces and into the atrium where it is exhausted thought the atrium roof openings. During the summer day the building uses an underground cooling by drawing the air into the building through a network of pipes buried in the ground using the thermal storage effects of the ground for pre-cooling. The ground cooling system reduces the supply air temperature by up to 8ºC during summer time peak temperatures of greater than 32ºC. The same system is used for pre-heating the ventilation air in winter. The heat generated by individuals, office equipment, lighting and l solar radiation is usually sufficient to maintain comfort temperatures. A hot water storage tank is heated up by solar collectors, waste heat from refrigeration equipment in the kitchen and from the local Empa-Eawag heating network. The vacuum tube collector system has a surface area of 50m^2 providing some 24,000 kWh of heat per year.

The design aimed to achieve a zero energy development in terms of energy consumption for heating and cooling and at least 1/3 of the electricity requirements provided by the building's own PV system. A 459m^2 2 array of photovoltaic cells with a capacity of 77kWp is situated on the roof supplies about 219,000kWh/a. The building meets the Swiss Minergie P Lable.

National conclusions

In the 1980s, Switzerland achieved considerable advances in the environmental field and in the establishment of a proper legal system. Currently, although Switzerland is making a number of proposals in the context of the future international climate regime (CO_2 global tax, financing of developing countries by industrialized countries, etc), its role as a pioneer seems to have been lost. However, not wanting to go it alone, Switzerland tends to align its position with those of other European Union countries.

The results obtained by the various policies and measures are encouraging, but remain insufficient to achieve the defined objectives. Thus, the reduction target stipulated by the CO_2 Act is a long way from being achieved (a difference of 0.5 million tons of CO_2 per year between the results and the overall objective), due to the fact that certain climate policy instruments have not been introduced or have been introduced late[19]. These include the CO_2 tax on fuels (introduction was delayed to January 2008), the promotion of natural gas and of biofuels (introduction delayed to July 2008) and fiscal incentives for vehicles (bonus system under discussion in parliament). It is clear that guidelines and more stringent laws should be put in place urgently and imperatively.

This has resulted in a significant legislative update, based on international targets for review (percentage reduction in CO_2 for example). The year 2008 was thus a pivotal year for Switzerland: emulation, new projects and redesigning the legislative system.

As in many other European countries, the transport in Switzerland is one of the main "sources" of CO_2. This phenomenon is often supported by low density development and urban sprawl, which produce the need of traveling over long distances to reach the work, shopping or leisure destinations. On the other hand, Switzerland is one of the country in which the public transport has the best image and reputation ("Swiss railways travel always on time"); this also helps the promotion and the success of many projects aiming at a systematic improvement of the public transport offer, and at a consequent reduction of the private car traffic, as one of the less efficient way of moving. Even if there are still big differences between the different parts of the country, there are many examples of good functioning public transport network with impressive results in term of increase of demand and transported passengers.

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XIX United Kingdom

Prof Phil Jones, Prof Chris Tweed and Joanne Patterson, Welsh School of Architecture, Cardiff University

National context

The United Kingdom of Great Britain and Northern Ireland, most commonly referred to as the United Kingdom (UK), consists of four countries: England, Scotland, Wales and Northern Ireland. It is a constitutional monarchy with three distinct systems of law: English law (which also applies in Wales), Northern Irish law and Scots law. Each of the three jurisdictions—England and Wales, Scotland and Northern Ireland—has its own building regulations. Wales is planning to introduce its own regulations to allow for the introduction of a zero carbon target for all new buildings by 2011.

Climate

The climate is temperate, with plentiful rainfall all year round. The temperature varies with the seasons but seldom drops below −10 °C or rises above 35 °C. The prevailing wind is from the southwest, bearing frequent spells of mild and wet weather from the Atlantic Ocean. Atlantic currents, warmed by the Gulf Stream, bring mild winters, especially in the west. Climate varies across the country as shown in the degree day values below.

Region	Mar 2008	Mar 2007	20-year average
South East England	280	260	259
Wales	274	260	263
Northern Ireland	299	282	279
North West England	318	267	287
West Scotland	314	272	292
East Scotland	316	280	296
NE Scotland	337	269	306

Table XIX.i - degree days for different regions across the UK

Demographics

England accounts for just over half of the total area of the UK, covering 130,410 square kilometres (50,350 sq mi). It has many large towns and cities, including six of the top 50 zones in the European Union. Scotland accounts for about a third of the total area of the UK. Glasgow is the largest city in Scotland, although Edinburgh is the capital and political centre. Wales accounts for less than a tenth of the total area of the UK. The main population centres are in the south, in the cities of Cardiff, Swansea and Newport. Northern Ireland accounts for just 14,160 square kilometres (5,470 sq mi). It has two main urban conurbations: Belfast in the east and Londonderry in the northwest.

At the April 2001 UK Census, the total population of the United Kingdom was 58,789,194 the third largest in the European Union (behind Germany and France) and the twenty-first largest in the world.

Carbon dioxide emissions

In the recently published report on carbon dioxide emissions based on regional assessments, the total CO_2 emissions for the UK is listed as 532 millions of tonnes, which is equivalent to 8.8 millions of tonnes per resident (ref.). This is the figure for 2006 and as it is based on local authority calculations does not include the carbon emissions from national sources such as shipping.

Energy in the UK

The UK is reliant on a variety of energy sources as shown in figure XIX.i below. It has recently reverted to being a net importer of energy having diminished oil and gas resources from the North Sea and coal from national mining. In addition, many of the first generation nuclear power stations are nearing the end of their useful productive lives, which will place an even greater burden on other fuels.

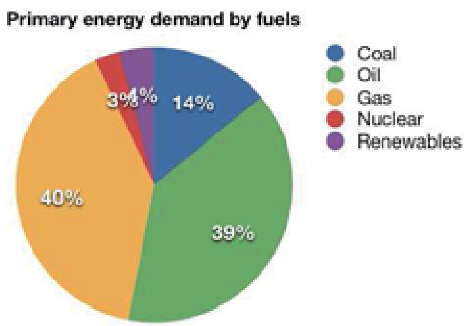

Figure XIX.i - primary energy demand by fuel type.

Building regulations

The UK has three sets of building regulations relevant to the implementation of EPBD. There are separate regulations for England and Wales, Scotland, and Northern Ireland. There are many similarities between these and the variations tend to follow differences in primary legislation. In all cases, the relevant central or regional government—Westminster, the Scottish Assembly or Northern Ireland Assembly—is responsible for the authoring of the legislation but local government is required to enforce their application. For England and Wales, the Department of Communities and Local Government (DCLG) is responsible for the building regulations. Building Control Officers, who are employed by local authorities, must approve designs and check for compliance during construction according to the regulations which have been written by central government. Building Control Officers, however, are consulted, along with other stakeholders, during the drafting or revision of the regulations, though the government is not obliged to take on board their recommendations.

At first glance, the process for enacting legislation seems complicated, but the stages are straightforward: pre-drafting or policy development; drafting; consultation; final proposals; making and laying; coming into operation. Each stage involves a range of stakeholders. Initial drafts of regulations are presented to panels representing the interests of industry and including experts in the field.

EPBD implementation

Calculation method

In the UK the National Calculation Method for the EPBD is defined by the Department for Communities and Local Government (DCLG). The UK relies on two calculation methods to demonstrate compliance with the EPBD. The Standard Assessment Procedure (SAP) is used for dwellings, whereas the Simplified Building Energy Model (SBEM) is used for non-domestic buildings. The UK's Building Research Establishment (BRE), formerly a state-run research laboratory, has been responsible for making both methods available to the public. SAP is derived from BREDEM (BRE Domestic Energy Model) but has been adapted to focus on carbon emissions rather than energy. SBEM was initially developed in the Netherlands but again BRE modified the method to make it suitable for wider use and for calculating carbon emissions. Details of SBEM are presented on the National Calculation Method website.

Energy performance requirements

Part L of the Building Regulations for England and Wales was revised in 2006 to address the performance requirements set out in Articles 4-6 of the EPBD for new and existing buildings. As with previous energy related building regulations, there are separate documents for domestic and non-domestic buildings. The main change is the introduction of two CO_2 emissions terms that determine the performance of a dwelling. Dwelling Emission Rate (DER) is the CO_2 emission in kg/m^2/year and must be no worse than the Target Emission Rate (TER) calculated for a dwelling. Other clauses in Part L are more or less literal adoptions of clauses used in the EPBD.

Energy performance certificates

Implementation of Article 7 requiring Energy Performance Certificates (EPCs) has been phased in during 2008: by 6th April, EPCs are required on construction for all dwellings. EPCs are also required for the construction, sale or rent of buildings other than dwellings with a floor area over 10,000 m^2; since 1st July 2008, EPCs have been required for the construction, sale or rent of buildings other than dwellings with a floor area over 2,500 m2; and finally, from 1st October 2008, EPCs have been required on the sale or rent of all remaining dwellings.
EPCs required on the construction, sale or rent of all remaining buildings other than dwellings. Display energy certificates (DECs) are required for all public buildings >1,000 m^2.

Inspection of systems

To satisfy Article 9, by 4th January 2009, first inspection of all existing air-conditioning systems over 250kW will have taken place. All remaining AC systems over 12kW will have been inspected by January 2011.

Other initiatives

In April 2007 the Code for Sustainable Homes replaced Ecohomes, developed by the Building Research Establishment (BRE), as the main sustainability assessment method for new housing in England (DCLG, 2008). The Code for Sustainable Homes defines six levels of compliance for dwellings, with each level progressively requiring an improvement over the energy regulations defined in Part L 2006. In addition to energy and carbon requirements, the Code sets minimum standards for materials, surface water run-off and waste at entry level. Levels 5 and 6 are the most demanding, culminating in a 'zero carbon' requirement.

Stamp Duty Land Tax - In October 2007, the UK government introduced new legislation to provide exemption from Stamp Duty on first purchases of zero carbon homes of less than £500,000 (UK Government, 2007). Currently, buyers pay between 1-4% of the purchase price as a tax. Zero carbon is defined by assessment via the SAP method described above.

Case study 1: Plas y Môr

Grŵp Gwalia, is a leading provider of social housing in south and mid Wales. The grŵp is well known in Wales as a pioneer in environmental architecture. Gwalia emphasises green construction and emerging clean technologies. Gwalia is also renowned for its use of sustainable materials in its buildings, particularly timber, constructed the first 5 and 6-storey timber frame building in Wales, at Aberystwyth and Swansea Universities.

Figure XIX.ii - Plas Y Môr residential scheme, Aberystwyth

The Building

Plas y Môr is a ground breaking project in the social housing sector in south Wales, UK. Completed in 2003, it provides independent living for older people, in an environment of mutual support. The development consists of 20 apartments for frail elderly people and 18 apartments for fit elderly people with accompanying facilities.

The building contains the following environmental features:

- 200mm timber-frame construction insulated with 200mm cellulose recycled newspaper.
- Passive solar gains.
- Warm air from glass garden extracted by thermostatically controlled fans and ducted into communal areas or exhausted as required.
- District heating by "biomass" boilers.
- 30m^2 of solar hot water panels for preheat of domestic hot water.
- Integration of solar hot water into the district heating system.
- Energy management systems.
- Optimisation of natural light to corridors by "top-glazing" and the use of "light-tubes"
- Organic paint systems and jute-based floor coverings.
- Hydraulic lime mortar to external brick walls.
- Water conservation measures.

The building incorporates both passive and active solar features, and a biomass wood pellet boiler. The biomass pellet system comprises 295kW Danish Passat wood pellet boilers serving the main building Low Pressure Hot Water heating system and the 3 hot water services cylinders (Roberts, 2008). During summer months, the boilers are turned off, with hot water provided solely by the solar water heating system. If the solar system cannot cope with the hot water demand, electric immersion heaters installed in the calorifiers provide for a maximum of 5% demand.

Since handover of the scheme in October 2003, problems in operation of the system have varied from complete breakdown to fluctuation in temperature, the latter as a result of poor fuel burn and increased level of clinker/ash. It was discovered that the main problem was a result of too high a moisture content in the wood pellets. Since March 2005, twice-weekly visits have been made to remove ash and clinker. This was originally planned as a weekly operation and therefore incurs additional maintenance expenditure but has resulted in efficient running of the system.

Meetings with the fuel supplier have established several new boiler maintenance procedures, as well as new standards of fuel, delivery frequencies and boiler parts provision. The EU standard for pellet moisture content is set at 10% and the supplier has recently installed a dryer to maintain consistently accurate pellets in terms of moisture content. Additional safeguards have been provided by restricting the wood supply to pure, uncontaminated sources. Fuel quality issues are now resolved resulting in a more even burn, less fluctuation in boiler temperature and therefore more efficient boiler operation.

The problems experienced with the boilers have raised the issue of providing a back-up heating system. However, at £50,000 this is an expensive option and would be fossil-fuelled by Liquid Petroleum Gas. Due to problems with siting fuel tanks close to an adjoining railway line, the provision of a mobile heating backup system, brought to site when needed, has been adopted as a more feasible option.

Decision making

It was developed as a partnership project between Gwalia Housing Group, Carmarthenshire County Council and the Welsh Assembly Government. All three partners provided a share of the funding. Gwalia provided the project management and development expertise.

Cost analysis

The cost of the scheme at £720/m^2 was relatively low for buildings of this type.

The original 3 year contract for pellets for the biomass boiler was £105 per tonne. Costs have now risen to £145 per tonne for a further three-year contract. Other options include an "oil-tracker" price per tonne set at 20% below the cost of heating oil, or a 5-year fixed-price contract at £155 per tonne.

Carbon analysis

The predicted energy collected by the solar collectors was estimated to be 21,450 KWh per year which could be described as "free" energy. Biomass systems are the only renewable systems that require fuel to be paid for, and this study examines the costs of the two boilers over the three to four year operation.

The first set of data provides the biomass energy consumption in kilowatt hours per annum, to be compared with other schemes. From the second set of data we can calculate energy costs per square metre. The final data gives the costs to the landlord of supplying electricity to the staff areas and other facilities at the scheme. Figures for the amount of wood pellets delivered to Plas y Môr for the four heating seasons from 2003 to 2007 are illustrated in Table 1, with the final column showing the total figure of tonnes delivered. Variations in delivery amounts over time reflect the fact that silos are filled alternatively according to which is full and which can accommodate a pellet load.

To work out the energy consumption based on the biomass figures, assuming a Low Heat Value:

One metric tonne of wood fuel yields 18GJ or 5 MWh of energy (equivalent to 5000 KWh).

We can then work out the amount of biomass energy used: using the financial year figures for four years since 2003*:

404.76 tonnes/4 = 101.19 tonnes x 5MWh = 505.95 MWh per year

* First and last years are incomplete and represent part year values.

This figure covers all the heating and hot water requirement for the building, including the individual flats and the communal areas and facilities provided at the scheme.

Cost wise, biomass deliveries (without maintenance costs) came to a total of £48,150 over four years, giving an annual average of £12,037. With a total area of 3,500 square metres, this yields a figure of £3.44 per m^2 for heating and hot water provision at Plas y Môr.

In comparison, predicted UK household energy use is 25MWh per year. Multiply by the number of flats at the scheme, gives a value of 950 MWh per year. Plas Y Mor uses 505.95 MWh per year including communal facilities. It can therefore be seen as being very energy efficient.

Electricity costs are individually metered to every flat and are administered by different energy providers, according to tenant choice. This is confidential information not provided to the landlord, but tenants are being approached to see if they are willing to provide this information in the future. We do however have The cost per year of the total electricity consumed is available to Grŵp Gwalia. From this figure we have calculated that the average weekly bill for tenants inclusive of all energy costs is £5.45 including heating, lighting, cooking, hot water and appliances.

In overall terms the building has performed as well as predicted and at 505.95MWh per year for domestic hot water and central heating it is considerably below the national average.

This level of savings in terms of energy has been made, by the inclusion of high levels of insulation, correct orientation, a compact plan, natural and passive ventilation, and the use of active solar technologies, along with the communal biomass heating system. The fact that the flats along with common areas, share the renewable energy features also reduces demand for fossil-fuels for heating and hot water provision. The remaining energy requirement is for electricity for lighting, cooking and appliances.

Key points

In the three years plus of its operation, Plas y Môr has provided a warm, comfortable and airy environment for its tenants and has proved popular with both staff and residents as the space includes both natural lighting and ventilation.

Some lessons learned include:

- Monitoring and evaluation of energy costs by way of utility bill comparisons will be required in the future. At the moment, the figures are not readily available.
- Commissioning monitoring equipment for the solar thermal and biomass systems would be beneficial, as comparisons between predicted and actual use, is then possible. Keeping checks on system performance is going to be an increasingly valuable investment in the low and zero carbon economy.
- Great care must be taken in the choice of biomass boilers to ensure they require as little manual attention as possible.
- The choice of fuel provider is critical and wherever possible, pellets should be sourced locally to reduce their carbon footprint. Users need to ensure that pellets have a moisture-content below 10% and are as near to natural as possible and correctly stored.
- A backup source of heating should be provided, that should preferably also be from a renewable source.

Planning legislation

Each country within the UK has its own planning systems which are devolved from the UK parliament. These are based on the Town and Country Planning Act of 1947 and are used to regulate land use and new building. The 1947 Act required that all development proposals should secure planning permission from the local authority. The need for development control is based on rapid urbanisation as a result of industrialisation and population growth resulting in pollution and significant loss of green land during the first half of the twentieth century.

The Town and Country Planning Act of 1990 consolidated many alterations that had occurred since 1947. This included the developer being subject to detailed arrangements and restrictions beyond those that a planning condition could impose and enabled negotiation, listed building and conservation areas, hazardous substances and consequential provisions.

There are 421 planning authorities in the UK who control planning legislation at two spatial levels:

Regional scale - planning authorities are required to provide local spatial planning policies which outline what is permitted across the area under control over the longer term to provide a vision of development for residents. The structure for this varies across the different UK countries.

The Local Development Framework is the spatial planning strategy introduced in England and Wales in 2006 to incorporate flexibility with regards to context and time which were previously inflexible.

Individual development – planning permission is sought from a planning authority to enable a development to be approved. This includes the change of use of a building or “building, engineering, mining or other operations in, on, over or under land, or the making of any material change in the use of any buildings or other land” (TCPA, 1990). Buildings that are considered architecturally or historically important are “listed”, and consent for modifications to listed buildings are more stringent.

Low/zero carbon in UK planning legislation

Planning legislation is a key way in which carbon reductions can be achieved as it is possible to exert some control of developments that are taking place. Reference to low carbon within UK planning policy has increased significantly in the past three years. However, much of this is in the form of generic statements responding to the issue of climate change, rather than providing guidance on direct measures for change within the built environment. For example, The Planning Policy Statement (PPS) on Climate Change published in December 2007 made it clear that tackling climate change is central to what is expected of good planning.

The Planning for a Sustainable Future White paper (2007) states that supporting the building of zero-carbon homes and business premises are key priorities. Buildings should be:

- low energy and produce lower carbon emissions;
- located to reduce the need to travel;

- make walking and cycling accessible, attractive and essential components of new development;
- support integrated public transport.

The Planning Act of 2008 includes a duty on councils to take action on climate change in their development plans; and to have regard to the desirability of achieving good design. In these three documents little guidance is provided on how to achieve this.

Within the UK Renewable Energy Strategy (DECC, 2009) a key deliverable is the need to change the pace of the planning system in order to delivery renewable energy, stating "Our planning system must enable renewable deployment in appropriate places, at the right time, and in a way that gives business the confidence to invest. Thus we must speed up the system and make it more predictable, while ensuring that we continue to protect our environment and natural heritage and respond to the legitimate concerns of local communities. Clearly we do not want to see large-scale renewable deployment in places where it is inappropriate. But in many more places where such deployment is both appropriate and desirable, we are determined to make faster progress."

More specific guidance and application of low carbon is now becoming available within planning documentation providing advice on how to achieve low carbon built environment. For example, The Planning Policy Statement for Eco-towns (2009) sets guidelines for new towns which are exemplar green developments of a minimum of 5000 homes. Ecotowns, initially in four locations across the UK, will be designed to meet the highest standards of sustainability, including low and zero carbon technologies and good public transport. This Planning Policy Statement (PPS) provides the standards any eco-town will have to adhere to and the list of locations identified with the potential for an eco-town.

In Wales the Planning Policy Wales of 2002 set out the ways in which the planning system can make an important contribution to wider initiatives to tackle the causes of climate change, and adapt to its current and future effects. This has been followed up with the Technical Advice Note (TAN) 22, Planning for sustainable buildings, (currently under consultation). This TAN explains how to apply the policy for sustainable building and covers:

- sustainable buildings standards,
- reducing carbon emissions by using the energy hierarchy in building design that reduce emissions in the most effective manner,
- preparing development proposals to deliver sustainable building standards,
- the role of local planning authorities,
- planning conditions and obligations,
- setting local requirements for sustainability on certain sites.

Commitment, quality and collaboration to enhance sustainable building standards are identified as key.

In England, changes to permitted development rights for domestic renewable technologies were introduced in April 2008 which has seen the requirements for planning permission for most microgeneration technologies lifted. This will increase opportunities for microgeneration as certain limited forms of development can be undertaken without the need to apply for planning permission. Solar PV and solar thermal (roof mounted), solar PV and solar Thermal (stand alone), biomass boilers and stoves, and CHP, ground source heat pumps, water source heat pumps are included under this (with some limitations). Microwind and Air Source Heat Pumps still have some legal technicalities to resolve.

The Merton Rule was developed and adopted by Merton Council in 2003. This borough wide prescriptive planning policy requires new developments to generate at least 10% of their energy needs from on-site renewable energy equipment. The most commonly accepted threshold is 10 homes or 1,000m^2 of non-residential development - though this is sometimes lower. Many other planning authorities have followed this lead. Although the target is not very high, it provides an example of a planning authority taking bold steps towards low carbon applications.

Traditionally the planning system has been seen by the public as development control for individual planning applications. However, the introduction of the Local Development Framework in England and Wales in 2006 will incorporate a large component of community involvement in preparing future planning policies. This will enable more transparency and a greater understanding of the need for a low carbon approach by the wider general public.

Urban case study: Warmer homes on a regional scale

Neath Port Talbot County Borough Council has a population of 134,468 and covers a geographical area of 44,217 hectares. Its economy has been dominated by heavy industry which collapsed during the 1970s and 1980s. Like other industrial areas, it combines a legacy of environmental pollution poor standards of housing and amenities and high levels of poverty and economic inactivity.

Figure XIX.iii - Typical housing in south Wales valleys

An analysis has been carried out on the housing stock for a local authority in Wales (Figure XIX.iii). Some 57,000 houses were surveyed and their energy use and associated CO_2 emissions estimated using the Energy and Environmental Prediction (EEP) model. The EEP model is a computer based framework that has been developed at the Welsh School of Architecture to be used as an environmental auditing and decision making tool for local authorities. It was designed to be used by planners and others in pursuit of sustainable development. The EEP model is based on Geographical Information System (GIS) techniques and brings together a large database that can be acted upon by sub-models within the model structure (see front cover illustration). The model can predict the effects of future planning decisions from a whole city level down to a more local level.

Sub-models currently within EEP include information about energy use and emissions produced by both domestic and non domestic properties, industrial processes and traffic that can be analysed independently or combined within the model framework to assess overall energy use and CO_2 emissions for a city or area.

The results from the domestic SAP rating analysis are shown in figure XIX.iv. The EEP model can then be used to assess the most appropriate package of energy saving measures to be applied to different house types in order to help local authorities plan for refurbishment. EEP was used to identify energy savings in through improvements in the domestic sector. The application of basic measures such as loft insulation, double glazing, new heating systems was shown to reduce the council's domestic energy use by 34% or 390,306 GJ /year and the CO_2 emissions would drop by 29% or 22,800 tonnes per year

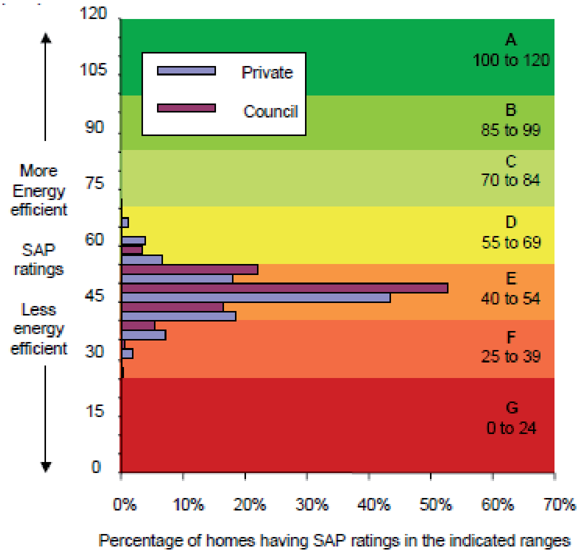

Figure XIX.iv - Distribution of SAP ratings for private and public housing in Neath Port Talbot

The "Bringing Warm Homes to Neath Port Talbot Scheme" was implemented to apply energy saving measures such as identified in the EEP analysis at whole local authority scale. The aim was to reduce the number of homes in fuel poverty and to improve energy efficiency across the whole Borough. This Scheme has also reduced carbon emissions by reducing the amount of energy used in houses included within the Scheme.

Fuel poverty is a major problem in the UK. The main cause of fuel poverty is a combination of poor efficiency in homes and low income. Other factors include the size of properties in relation to the number of people living in them and the cost of fuel. It is estimated that there were approximately 167,000 households in Wales suffering from fuel poverty in 2005, which is about 14% of all households. This is predicted to have increase to 250,000 in 2006 as a result of rising fuel prices.

The Scheme has seen an investment of over £10million to install energy efficiency measures in the Boroughs housing stock. Energy efficiency measures included within the Scheme include:

- Cavity Wall insulation,
- Loft insulation,

- Hot water cylinder insulation jackets,
- New boiler and heating system,
- New gas supplies,
- External cladding,
- Compact Florescent lamps.
- Energy efficiency advice.

A major advantage of the Scheme, compared to many others, is that *every* individual household within the County has been approached. This enables all households experiencing fuel poverty to be identified, with all households offered the same energy efficiency opportunities if eligible. A blanket based approach, as used in the Scheme, provides a mechanism that enables all households in need to be identified rather than targeting funding in areas that are believed to be most in need which can exclude households that are actually most in need.

The Scheme has been evaluated by the Welsh School of Architecture in order to provide an independent assessment of this “blanket” approach to the installation of energy efficiency measures.

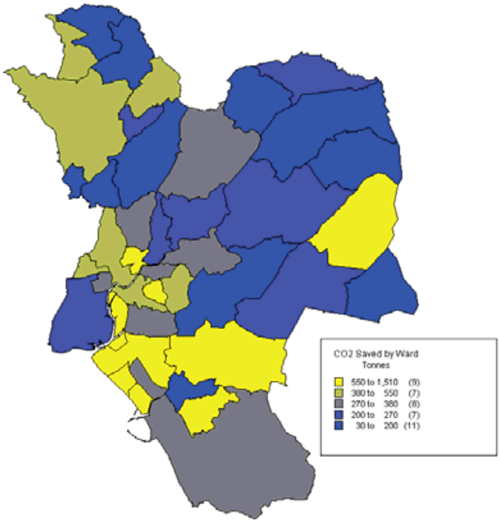

Figure XIX.v - CO_2 savings on a ward basis

Achievements of the Scheme include:

- A total of 28,799 energy efficiency measures have been installed. 18,832 properties have been improved with at least one substantial energy efficiency measure.
- A household questionnaire has shown that residents feel that the installations have had a positive impact on the physical characteristics of their household. Biggest improvements have related to a reduction in condensation and a reduction in draughts.
- 18,500 tonnes of CO_2 emissions per year are saved as a result of the scheme. This is a 9.2% saving of CO_2 which illustrates a significant cut in CO_2 emissions for the area.
- 2,305 households have been removed from fuel poverty.

City case study: Cardiff

Cardiff is the capital and the largest city within the principality of Wales. Located on the coast, to the south east of the Principality, Cardiff is the largest of the 22 local authorities in Wales and the14th largest settlement in the UK in 2001. Wales is just one of just three countries in the world with the commitment to Sustainable Development built into its constitution and its policies reflect this wherever possible

Cardiff is a relatively flat city bounded by hills to the east, north and west and the coast to the south. Its geographical features were influential in its development as the world’s largest coal port during last century, due its proximity to the coal fields of the south Wales valleys and the sea. Whilst 10% of Wales population live in Cardiff, it is also one of the oldest multi-cultural communities in the UK as a result of its industrial heritage.

Location	Latitude	51.49 ° N
	Longitude	3.18 ° W
	Size	144km^2
Climate	Temperature	4.5 °C - 16 °C
	Av. Rainfall	1,065 mm (41.9 in).
Population	1991	
	2001	305,353
	2007 (est)	321,000
	Density	2,222 inhabitants per Km^2
	Households (2001)	127,476
	Workforce	194,600
Domestic energy consumption	Space/hot water/cooking/ lighting/ appliances	9,898 kwh/capita/yr

Table XIX.ii - Characteristics of Cardiff

The Cardiff Community Strategy 2007-17, a key policy document for the city, commits the Council to for promote the economic, social and environmental wellbeing of the city, and to contribute to the achievement of sustainable development in the UK. Cardiff will work with partners to develop a climate change action plan, and work towards the aspiration of becoming a Carbon Lite Cardiff.

Buildings

Traditionally, housing in Wales comprises of terraced, semi-detached and detached single and two storey housing (80% of households). The city's growth has been outward, with populations moving from the Victorian and Edwardian city centre areas into the suburbs. In recent years, Cardiff, particularly in the Bay area, has seen an increase in low rise apartment blocks (3-4 floors) of both new build and renovation of industrial buildings, mainly on brownfield land. These are interspersed with occasional high rise towers of up to 20 storeys which have dramatically altered the city skyline within the past 5 years.

Cardiff are currently regenerating a number of housing sites across the city in partnership with Leadbitter Group.One of the key drivers of the partnership is a low energy focus in order to address the issue of fuel poverty. Low carbon measures included within the scheme are ground source heat pumps, timber frame construction, solar hot water panels and photovoltaic panels.

Transport

Cardiffs existing transportation infrastructure is under increasing pressure due to economic growth and changing lifestyles. Cardiff is ideally situated for sustainable transport systems to function effectively, being compact and relatively flat. The establishment of the Cardiff Transport Partnership marks an important step forward to ensuring the safe and efficient movement of people throughout the city. 80% of Cardiff residents travel less than 5 miles to work which is considered to be a distance that is reasonable to travel by foot or bicycle.

Cardiff is known as the "City of Parks", indeed parks account for around 10% of the area of the city. Cardiff has in excess of 10 acres of green space per 1000 population – although this is not necessarily in the most appropriate place for use and is not all recreational space it can be utilised to a much greater extent for sustainable transport.

In March 2009 it was announced that Cardiff will become Wales' first Sustainable Travel City and that £28.5m will be invested by Cardiff County Council and the Welsh Assembly Government on transport improvements across the city. Through a number of different projects the council will create safe, reliable and sustainable modes of transport that will provide positive environmental, social and economic results across the city. This will include six key schemes that will help reduce the number of cars on the over-crowded streets of the capital. Measures will include a free city centre shuttle service, free bike hire scheme, new park and ride centres and improved walking and cycling routes.

Ecological footprint

Cardiff's ecological footprint is equal to 82% of the land area of Wales (Collins A, Flynn A and Netherwood A, 2005). An ecological footprint is expressed in global hectares (gha) of "earthshare". If we divide the bio-productive land and sea on the planet by the number of people who need to use it, an earth-share of only 1.89 gha per person is available (WWF, 2004). A Cardiff citizen therefore has an 'unsustainable' footprint of 5.59 gha, meaning if everyone on earth lived the same lifestyles as people in Cardiff, we would need almost three planets worth of resources to survive.

Looking forward

Cardiff has committed itself to developing of Cardiff as a carbon-lite city based on energy efficiency, integrated transport, encouragement of green industries and greater proportions of energy being secured from renewable sources from 2007 – 2017. Collaboration and partnerships are being established to agree on ways forward, the next step is to make low carbon happen.

National conclusions

Even within the relatively short period covered by the COST C23 Action, there have been significant moves towards reducing carbon dioxide emissions resulting from the built environment in the UK. The requirements of the initial EPBD legislative responses are in the process of being surpassed by tougher "zero-carbon" standards for new buildings, most notably in Wales by 2011, and 2016 in the rest of the UK. This rate of change in building legislation is unprecedented in modern times and the construction industry will need a period of readjustment to take on board new skills and develop new working practices and supply chains.

Cost is one of the most talked about concerns in the construction and housing industries. Although costs vary considerably depending on location and type of construction, it is clear that there is a large rise to achieve Code Level 5—zero carbon apart from appliances—and even more for Code Level 6—zero carbon for everything. Observers and those involved in the delivery of the built environment are beginning to question to the wisdom of seeking zero carbon or carbon neutrality through reductions in demand, arguing that it may be more cost-effective to "decarbonise" the central supply of energy to buildings.

A further development in the pursuit of a low carbon built environment is the shifting responsibilities between different government agencies. There are two main professions responsible for enforcing regulations related to the built environment: environmental planners and building control officers. Currently, buildings control officers are responsible for legislation that concerns the performance of buildings, whereas planners are responsible for everything outside the building. This is likely to change, with planners assuming responsibility for ensuring new developments are zero carbon, according to government definitions. Whether planners have the skills to enforce these emerging regulations, specifically, and both professions have the necessary skills, in general, remains to be seen.

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The Organisation of COST

COST- the acronym for European Cooperation in Science and Technology- is the oldest and widest European intergovernmental network for cooperation in research. Established by the Ministerial Conference in November 1971, COST is presently used by the scientific communities of 35 European countries to cooperate in common research projects supported by national funds.

The funds provided by COST - less than 1% of the total value of the projects - support the COST cooperation networks (COST Actions) through which, with EUR 30 million per year, more than 30 000 European scientists are involved in research having a total value which exceeds EUR 2 billion per year. This is the financial worth of the European added value which COST achieves.

A "bottom up approach" (the initiative of launching a COST Action comes from the European scientists themselves), "à la carte participation" (only countries interested in the Action participate), "equality of access" (participation is open also to the scientific communities of countries not belonging to the European Union) and "flexible structure" (easy implementation and light management of the research initiatives) are the main characteristics of COST.

As precursor of advanced multidisciplinary research COST has a very important role for the realisation of the European Research Area (ERA) anticipating and complementing the activities of the Framework Programmes, constituting a "bridge" towards the scientific communities of emerging countries, increasing the mobility of researchers across Europe and fostering the establishment of "Networks of Excellence" in many key scientific domains such as: Biomedicine and Molecular Biosciences; Food and Agriculture; Forests, their Products and Services; Materials, Physical and Nanosciences; Chemistry and Molecular Sciences and Technologies; Earth System Science and Environmental Management; Information and Communication Technologies; Transport and Urban Development; Individuals, Societies, Cultures and Health. It covers basic and more applied research and also addresses issues of pre-normative nature or of societal importance.

Web: http://www.cost.esf.org

This publication summarises the activities of the COST C23 Action entitled 'Strategies for a Low Carbon Urban Built Environments (LCUBE)' which took place over the period 2004 to 2009.

The main objective of the COST C23 Action was to investigate, through a network of nineteen countries across Europe,

'how carbon reductions can be achieved through appropriate design and management of the urban built environment'.

This involved investigating the built environment at building and urban scale, focusing on minimising energy use and associated carbon dioxide emissions.

The COST C23 Action investigated how nineteen EU member states were active in reducing carbon dioxide levels in the built environment, not only in line with buildings meeting the requirements of the Energy Performance of Buildings Directive (EPBD), but also taking standards beyond that and looking at how national and regional planning initiatives are being developed to reduce the energy use of urban areas. A collection of case studies are included that illustrate the development and implementation of low carbon strategies at urban and building scales.

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